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REPORT ON PROGRESS IN NON-EUCLIDEAN GEOMETRY.

IT marks an epoch in the history of mathematics that at a meeting of a great Association for the advancement of science there should be presented by invitation a Report on non-Euclidean geometry.

Its two creators, Lobachévski, who misnamed it Imaginary Geometry, and Bolyai János, under the nobler name Science Absolute of Space, failed utterly while they lived, to win any appreciative attention for what is to-day justly honored as one of the profoundest advances of all time. The only recognition, the only praise of the achievement of Lobachévski ever printed in his lifetime was by Bolyai Farkas, the father of his brilliant young rival, and appeared in a little book with no author's name on the title page, and which we have no evidence that Lobachévski ever saw, a little book so rare that my copy is probably the only one on the Western Continent.

When after more than forty years they were rescued from oblivion by Baltzer and Hoüel in 1866, still envious time gave them back only with an aspersion against the genuineness of their originality. A cruel legend tarnished still their fame so long delayed, so splendidly deserved.

Even when their creation had reached the high dignity of being made the subject of courses of lectures for consecutive semesters at the University of Göttingen, yet

on page 175 of the second impression of these lectures, 1893, we still find Felix Klein saying, "Kein Zweifel bestehen kann, dass Lobatscheffsky sowohl wie Bolyai die Fragestellung ihrer Untersuchungen der Gaussischen Anregung verdanken."

It is a privilege to begin my report by announcing the rigorous demonstration that this ungenerous legend is untrue. This point need not further delay us, since it has been treated by me at length in SCIENCE, N. S., Vol. IX., No. 232, pages 813–817, June 9, 1899.

What a contrast to the pathetic neglect of its creators, Lobachévski dying blind, unrecognized, without a single follower, Bolyai János dying of disgust with himself and the world, lies in the fact that less than a year ago our American magazine, the *Monist*, secured from the famous Poincaré, at great cost, a brilliant contribution to this now universally interesting subject, which I had the honor, through my friend T. J. McCormack, of reading in the original French manuscript.

This extraordinary paper, published only in English translation, appears in the *Monist*, Vol. 9, No. 1, Oct., 1898, pages 1–43. In the first section of his greatest work, Lobachévski says: "*Juxtaposition* (contact) is the distinctive characteristic of solids, and they owe to it the name *geometric solids*, when we retain this attribute, taking into consideration no others whether essential or accidental.

"Besides bodies, for example, also time, force, velocity are the object of our judgment; but the idea contained in the word juxtaposition does not apply thereto. In our mind we attribute it only to solids, in speaking of their composition or dissection into parts.

"This simple idea, which we have received directly in nature through the senses, comes from no other and consequently is subject to no further explanation. Two solids *A* and *B*, touching one another, form a single geometric solid *C*, in which each of the component parts *A*, *B* appears separate without being lost in the whole *C*. Inversely, every solid *C* is divided into two parts *A* and *B* by any *section S*.

"By the word section we understand here no new attribute of the solid, but again a juxtaposition, expressing thus the partition of the solid into two juxtaposed parts.

"In this way we can represent to ourselves all solids in nature as parts of a single whole solid which we call space."

Poincaré starts off somewhat differently. He says: "We at once perceive that our sensations vary, that our impressions are subject to change. The laws of these variations were the cause of our creating geometry and the notion of geometrical space.

"Among the changes which our impressions undergo, we distinguish two classes:

"(1) The first are independent of our will and not accompanied by muscular sensations. These are *external changes* so-called.

"(2) The others are voluntary and accompanied by muscular sensations. We may call these *internal changes*.

"We observe next that in certain cases when an external change has modified our impressions, we can, by voluntarily provoking an internal change, re-establish our primitive impressions. The external change, accordingly, can be *corrected* by an internal change. External changes may consequently be subdivided into the two following classes:

"1. Changes which are susceptible of being corrected by an internal change. These are *displacements*.

"2. Changes which are not so susceptible. These are *alterations*. An immovable being would be incapable of making this distinction. *Such a being, therefore, could never create geometry*, even if his sensations were variable, and even if the objects surrounding him were movable."

How like what Lobachévski said more than sixty years before: "We cognize directly in nature only motion, without which the impressions our senses receive are not possible. Consequently, all remaining ideas, for example, geometric, are created artificially by our mind, since they are taken from the properties of motion; and therefore space in itself, for itself alone, does not exist for us."

Poincaré continues: "*the aggregate of displacements is a group.*" At once rise before us the great names Riemann, Helmholtz, Sophus Lie. In fact Poincaré's next section is merely a restatement of part of Riemann's marvellous address, published 1867, on the hypotheses at the basis of geometry.

Again, though the work of Helmholtz did not contain the group idea, yet it had put the problem of non-Euclidean geometry into the very form for the instrument of Sophus Lie, who calls it the Riemann-Helmholtz Space-problem.

To the genius of Helmholtz is due the conception of studying the essential characteristics of a space by a consideration of the movements possible therein.

Felix Klein it was who first called the attention of Lie to this work of Helmholtz, before then unknown to Lie, and pointed out its connection with Lie's Theory of Transformation groups, inciting him to a group-theory investigation of the problem. In 1886 Lie gave briefly his weightiest results in a note: "Bemerkungen zu v. Helmholtz' Arbeit über die Thatsachen, die der Geometrie zu Grunde liegen," in the Berichte of the Saxon Academy, where, in 1890, he gave his completed work in two papers, 'Ueber die Grundlagen der Geometrie' (pp. 284–321, 355–418). The whole investigation published in Volume III. of his 'Theorie der Transformationsgruppen,' 1893, was in 1897 awarded the first Lobachévski Prize. Felix Klein declared that it excels all comparable works so absolutely that a doubt about the award could scarcely be possible. Lie gives two solutions of the problem. In the first he investigates in space a group possessing free mobility in the infinitesimal, in the sense, that if a point and any line-element through it be fixed, continuous motion shall still be possible; but if besides any surface element through the point and line-element be fixed, then shall no continuous motion be possible. The groups in tri-dimensional space possessing in a real point of general position this free mobility, Lie finds to be precisely those characteristic of the Euclidean and two non-Euclidean geometries. Strangely enough, for the seemingly analogous and simpler case of the plane or two-dimensional space these are not the only groups. There are others where the paths of the infinitesimal transformations are spirals. Without the group idea, Helmholtz had reached this reality, and as a consequence concluded that also to characterize our tri-dimensional spaces a new condition, a new axiom, was needed, that of *monodromy*. It is one of the most brilliant results of Lie's second solution of the space problem, that starting from transformation-equations with three of Helmholtz's four assumptions, he proves that the fourth, the famous 'Monodromie des Raumes,' is, in space of three dimensions, wholly superfluous. What a demonstration of the tremendous power of Lie's Group Theory! Lie's method in general, as it appears in the Berichte, is the following:

Consider a tri-dimensional space, in which a point is defined by three quantities x, y, z.

A movement is defined by three equations: $x_1 = f(x, y, z)$; $y_1 = \varphi(x, y, z)$; $z_1 = \psi(x, y, z)$.

By this transformation an assemblage, A, of points (x, y, z) becomes an assemblage, A', of points (x_1, y_1, z_1).

This represents a movement which

changes A to A'. Now make, in regard to the space to be studied, the following assumptions:

(B) In reference to any pair of points which are moved, there is *something* which is left unchanged by the motion. That is, after an assemblage of points, A, has been turned by a single motion into an assemblage of points, A', there is a certain function, Ω, of the coördinates of any pair of the old points (x_1, y_1, z_1), (x_2, y_2, z_2) which equals that same function, Ω, of the corresponding new coördinates (x_1', y_1', z_1'), (x_2', y_2', z_2'); that is

$$\Omega(x_1', y_1', z_1', x_2', y_2', z_2') = \Omega(x_1, y_1, z_1, x_2, y_2, z_2).$$

This *something* corresponds to the generalized idea of distance interpreted as independent of measurement by superposition of an unchanging sect as unit for length. Moreover assume:

(C) If one point of the assemblage is fixed, every other point of this assemblage, *without any exception*, describes a surface (a two-dimensional aggregate). When two points are fixed, a point in general (exceptions being possible) describes a curve (a one-dimensional aggregate). Finally, if three points are fixed, all are fixed (exceptions being possible). Then Lie proves exhaustively that the group consists either of all motions of Euclidean space or of all motions of non-Euclidean space.

The result is a remarkable one, demonstrating that the group of Euclidean motions and the group of non-Euclidean motions are, in tri-dimensional space, the only groups in which exists in the strict sense of the word free mobility. Thus free motion in the strict meaning of the word can happen in three and only three spaces, namely, the traditional or Euclidean space, and the spaces in which the group of movements possible is the projective group transforming into itself one or the other of the surfaces of the second degree $x^2 + y^2 + z^2 \pm 1 = 0$.

To the fundamental assumption which completely characterizes these three groups, Lie gives also this form:

"If any real point y_1^0, y_2^0, y_3^0 of general position is fixed, then all real points x_1, x_2, x_3, into which may still shift another real point x_1^0, x_2^0, x_3^0, satisfy a real equation of the form:

"$W(y_1^0, y_2^0, y_3^0;\ x_1^0, x_2^0, x_3^0;\ x_1, x_2, x_3) = 0$, which is not fulfilled for $x_1 = y_1^0$, $x_2 = y_2^0$, $x_3 = y_3^0$, and which represents a real surface passing through the point x_1^0, x_2^0, x_3^0.

"About the point y_1^0, y_2^0, y_3^0 may be so demarcated a triply extended region, that on fixing the point y_1^0, y_2^0, y_3^0, every other real point $x_1^0, x_2^0, x^0{}_3$ of the region can yet shift continuously into every other real point of the region, which satisfies the equation $W = 0$ and which is joined to the point x_1^0, x_2^0, x_3^0 by an irreducible continuous series of points."

It is a satisfaction to the world of science that Lie's vast achievements were recognized while he lived. Poincaré accepts and expounds his doctrine, saying in the article already mentioned: "The axioms are not analytical judgments *a priori;* they are conventions. * * * Thus our experiences would be equally compatible with the geometry of Euclid and with a geometry of Lobachévski which supposed the curvature of space to be very small. We choose the geometery of Euclid because it is the simplest.

"If our experiences should be considerably different, the geometry of Euclid would no longer suffice to represent them conveniently, and we should choose a different geometry."

When on November 3, 1897, the great Lobachévski prize was awarded to Lie, three other works were given honorable mention. The first of these is a thesis on non-Euclidean geometry by M. L. Gérard, of Lyons. Lovers of the non-Euclidean geometry are naturally purists in geometry, and keenly appreciate Euclid's using solely such

figures as he has rigorously constructed. They understand that problems of construction play an essential part in a scientific system of geometry. Far from being solely, as our popular text-books suppose, practical operations, available for the training of learners, they have in reality, as Helmholtz declares, the force of existential propositions. Therefore is evident the high import of Gérard's work to establish the fundamental propositions of non-Euclidean geometry without hypothetical constructions other than the two assumed by Euclid: 1. Through any two points a straight line can be drawn; 2. A circle may be described from any given point as a center with any given sect as radius. Gérard adds explicitly the two assumptions: 3. A straight line which intersects the perimeter of a polygon in a point other than one of its vertices intersects it again; 4. Two straights, or two circles, or a straight and a circle, intersect if there are points of one on both sides of the other.

Upon these four hypotheses, perfecting a brilliant idea of Battaglini (1867), Gérard establishes the relations between the elements of a triangle.

Lobachévski never explicitly treats the old problems changed by transference into the new geometric world, such as "Through a given point to draw a parallel to a given straight"; nor yet the seemingly impossible problems now in it capable of geometric solution, such as "To draw to one side of an acute angle the perpendicular parallel to the other side"; "To square the circle."

These would be sought in vain in the two quarto volumes of Lobachévski's collected works. Bolyai János, in his all too brief two dozen pages, gives solutions of them startling in their elegance.

But in establishing his theory, he uses, for the sake of conciseness, the principle of continuity even more freely than does Lobachévski.

Gérard, in the second part of his memoir, gives the elements of non-Euclidean analytic geometry, and in the third part, a strict treatment of equivalence.

Even Euclid, in proving his I., 35, "Parallelograms on the same base, and between the same parallels, are equal to one another," does not show that the parallelograms can be divided into pairs of pieces admitting of superposition and coincidence. He uses rather the assumption explicitly set forth by Lobachévski, "Two surfaces are equal when they are sums or differences of congruent pieces." But Creswell in his *Treatise of Geometry*, showed how to cut the parallelograms into parts congruent in pairs. The same can be done for Euclid I., 43, "The complements of the parallelograms, which are about the diagonal of any parallelogram are equal." Hence, we may use the definition: Magnitudes are equivalent, which can be cut into parts congruent in pairs. This method I applied to the ordinary Euclidean geometry in my Elementary Synthetic Geometry before the appearance of Gérard's work, where it is extended to the non-Euclidean.

Regarding the first assured construction of Euclid and Gérard: "A straight line can be drawn through any two points," W. Burnside has given us a charming little paper in the *Proceedings of the London Mathematical Society*, Vol. XXIX., pp. 125–132 (Dec. 9, 1897), enitled 'The Construction of the Straight Line Joining Two Given Points.' Euclid's postulate implies the use of a ruler or straight-edge of any required finite length. The postulate is clearly not intended to apply to the case in which the distance between the two points is infinite. In fact, Euclid I., 31, gives a compass and ruler construction for the line when one of the points can be reached while the other cannot. The other exceptional case when neither point can be reached, *i. e.*, when two given points are the points

at infinity on two non-parallel lines, is not dealt with by Euclid.

In elliptic space any one point can be reached from any other by a finite number of finite operations. The line joining two given points can therefore be always constructed with the ruler alone. In hyperbolic space, if we deal with projective geometry, we must assume that *every* two straight lines in a plane determine a point. When the two straight lines are non-intersectors, the point can neither be a finite point nor a point at infinity. Such a point is termed an 'ideal' point. The problem of constructing the straight line joining two given points involves therefore three further cases; namely, (IV) that in which one of the points is a finite point and the other an ideal point; (V) that in which one is a point at infinity and the other an ideal point; (VI) that in which both points are ideal points.

It is a pleasure to signal the appearance, within the past year, of the second volume of the exceedingly valuable work of Dr. Wilhelm Killing, 'Einführung in die Grundlagen der Geometrie,' (Paderborn, 1898).

With Killing's name will be associated the tremendous difference living geometers find between the properties of a finite region of space, and the laws which pertain to space as a whole. Of the word *direction* he says "it can only be given a meaning when the whole theory of parallels is already presupposed."

The pseudo-proof of the parallel postulate still given in current text-books, for example, by G. C. Edwards in 1895, Killing calls the Thibaut proof, saying that it has especial interest because its originator, who was professor of mathematics at Göttingen with Gauss, published the attempt at a time, 1818, when Gauss had already called attention to the failure of attempts to prove this postulate, and declared that we had not progressed beyond where Euclid was 2000 years before.

But Killing is here in error when he supposes Thibaut the originator of this popular pseudo-proof. It was given in 1813 by Playfair in his edition of Euclid, in a Note to I., 29. It was very elegantly shown to be a fallacy by Colonel T. Perronet Thompson, of Queen's College, Cambridge, in a remarkable book called 'Geometry without Axioms,' of which the third edition is dated 1830, a book seemingly unknown in Germany, since Engel and Staeckel copy from Riccardi the title (with the mistake 'first books' for 'first book') under the date 1833, which is the date of the fourth edition.

Killing has won an important place by investigating the question, what varieties of connection of space are compatible with the different elemental arcs of constant curvature. Riemann, Helmholtz and Lie consider only a region of space, and give analytic expressions for the vicinity of a point. If this region be extended, the question is, what kind of connection of space can result.

Killing shows there are different possibilities, really a series of topologically different forms of space with Euclidean, Lobachévskian, Riemannian geometry in the bounded, simply connected region.

The germinal idea is due to Clifford, who, in an unprinted address before the Bradford meeting of the British Association (1873), 'On a surface of zero curvature and finite extent,' and also by a remark in his paper 'Preliminary sketch of biquaternions,' called attention to a recurrent surface in single elliptic space, which has everywhere zero for measure of curvature, yet is nevertheless of finite area.

Similarly complete universal spaces are found of zero or negative measure of curvature, which nevertheless are only of finite extent. Since there is no way of proving

that the whole of our actual space can be moved in itself in ∞^6 ways, it may possibly be, after all, one of these new Clifford spaces. Free mobility of bodies may only exist while they do not surpass a certain size.

Killing devotes an interesting section, over seven pages, to Legendre's definition of the straight line as the shortest distance between two points. He emphasizes three principle reasons why this is inadmissible. These are (*a*) since the possibility of measurement for all lines is presumed beforehand, which is not allowable; (*b*) since before the execution of the measurement there must be a measuring standard, but this is first given by the straight line; (*c*) since the existence of a minimum is not evident, on the contrary can be demanded only as an assumption.

The first objection was always conclusive, yet it strengthens every day, for our new mathematics knows of lines, real boundaries between two parts of the plane, to which the idea of length is inapplicable.

Under the title 'Universal Algebra,' one would scarcely look for a treatise on non-Euclidean geometry. Yet the first volume of Whitehead's admirable work (Cambridge, 1898, pp. 586) devotes more than 150 pages to an application of Grassmann's Calculus of Extension to hyperbolic, elliptic, parabolic spaces. So devoted is he, that we find him saying: "Any generalization of our space conceptions, which does not at the same time generalize them into the more perfect forms of hyperbolic or elliptic geometry, is of comparatively slight interest." He emphasizes the fact that the three-dimensional space of ordinary experience can never be proved parabolic. "The experience of our senses, which can never attain to measurements of absolute accuracy, although competent to determine that the space-constant of the space of ordinary experience is greater than some large value, yet cannot, from the nature of the case, prove that this space is absolutely Euclidean."

From the many important contributions by Whitehead may be singled out as especially timely his development of a theorem of Bolyai János to which F. S. Macauly called especial attention in the second of his able articles entitled, John Bolyai's 'Science Absolute of Space' (*The Mathematical Gazette*, No. 8, July, 1896, pp. 25–31; No. 9, October, 1896, pp. 49–60). Macauly says, p. 53, "Finally follows a theorem (§ 21), which is, undoubtedly, the most remarkable property of hyperbolic space, that the sum of the angles of any triangle formed by *L*-lines on an *F*-surface is equal to two right angles. On this theorem Bolyai remarks: (Halsted's Bolyai, 4th Ed., p. 18), 'From this it is evident that Euclid's Axiom XI., and all things which are claimed in geometry and plain trigonometry hold good *absolutely* in *F*, *L*-lines being substituted in place of straights. Therefore, the trigonometric functions are taken here in the same sense (are defined here to to have the same values) as in Σ (as in Euclidean geometry); and the periphery of the circle, of which the *L*-form radius $= r$ in *F*, is $= 2\pi r$, and likewise the area of circle with radius r (in *F*) $= \pi r^2$ (by π understanding half the periphery of circle with radius 1 in *F*, or the known 3.1415926 * * *).'"

Whitehead, in his Universal Algebra, § 262, recurs to this important point, saying: "The idea of a space of one type as a locus in space of another type, and of dimensions higher by one, is due partly to J. Bolyai, and partly to Beltrami. Bolyai points out that the relations between lines formed by great circles on a two-dimensional limit-surface are the same as those of straight lines in a Euclidean plane of two dimensions. Beltrami proves by the use of the pseudosphere, that a hyperbolic space of any number of dimensions can be considered as a locus in Euclidean space of

higher dimensions. There is an error, popular even among mathematicians, misled by a useful technical phraseology, that Euclidean space is in a special sense flat, and that this flatness is exemplified by the possibility of a Euclidean space containing surfaces with the properties of hyperbolic and elliptic spaces. But the text shows that this relation of hyperbolic to Euclidean space can be inverted. Thus no theory of the flatness of Euclidean space can be founded on it." Whitehead has since followed up his point in a very important and powerful paper in the *Proceedings of the London Mathematical Society*, Vol. XXIX., pp. 275–324, March 10, 1898, entitled 'The Geodesic Geometry of Surfaces in non-Euclidean Space.' He there says, "The relations between the properties of geodesics on surfaces and non-Euclidean geometry, as far as they have hitherto been investigated, to my knowledge, are as follows:

"It has been proved by Beltrami that the 'geodesic geometry' of surfaces of constant curvature in *Euclidean* space is the same as the geometry of straight lines in planes in elliptic or in hyperbolic space, according as the curvature of the surface is positive or negative.

"The geometry of great circles on a sphere of radius ρ in elliptic space of 'space-constant' γ is the same as the geometry of straight lines in planes in elliptic space of space-constant $\gamma \sin \frac{\rho}{\gamma}$.

"The geometry of great circles on a sphere of radius ρ in hyperbolic space of 'space-constant' γ is the same as the geometry of straight lines in planes in elliptic space of space-constant $\gamma \sin \mathrm{h} \frac{\rho}{\gamma}$.

"The geometry of geodesics (that is, lines of equal distance), on a surface of equal distance, σ, from a plane in hyperbolic space of space-constant γ, is the same as that of straight lines in planes in hyperbolic space of space-constant $\gamma \cos \mathrm{h} \frac{\sigma}{\gamma}$.

"Finally, the geometry of geodesics (that is, limit-lines), on a limit surface in hyperbolic space—which may be conceived either as a sphere of infinite radius or as a surface of equal, but infinite, distance from a plane—is the same as that of straight lines in planes in Euclidean space.

"The preceding propositions are due directly, or almost directly to John Bolyai, though, of course, he only directly treats of hyperbolic space.

"From the popularization of Beltrami's results by Helmholtz, and from the unfortunate adoption of the name 'radius of space curvature' for γ (here called the space-constant), many philosophers, and, it may be suspected from their language, many mathematicians, have been misled into the belief that some peculiar property of flatness is to be ascribed to Euclidean space, in that planes of other sorts of space can be represented as surfaces in it. This idea is sufficiently refuted, at least as regards hyperbolic space, by Bolyai's theorem respecting the geodesic geometry of limit surfaces. For a Euclidean plane can thereby be represented by a surface in hyperbolic space.

"It is the object of this paper to extend and complete Bolyai's theorem by investigating the properties of the general class of surfaces in any non-Euclidean space, elliptic or hyperbolic, which are such that their geodesic geometry is that of straight lines in a Euclidean plane.

"Such surfaces are proved to be real in elliptic as well as in hyperbolic space, and their general equations are found for the case when they are surfaces of revolution.

"In hyperbolic space, Bolyai's limit-surfaces are shown to be a particular case of such surfaces of revolution. The surfaces

fall into two main types; the limit surfaces form a transition case between these types. In elliptic space there is only one type of such a surface of revolution.

"The same principles would enable the problem to be solved of the discovery in any kind of space of surfaces with their 'geodesic' geometry identical with that of planes in any other kind of space."

So that which Macauly designated as 'undoubtedly the most remarkable property of hyperbolic space' has been by Whitehead not only generalized for hyperbolic space but extended to elliptic space.

Bolyai János seemed fully to realize the weight, the scope, the possibilities, the meaning of his discovery. He returns to it in § 37, where he uses the proportionality of similar triangles in F to solve an essential problem in S (hyperbolic space). Then he adds: "Hence, easily appears (L-lines being given by their *extremities alone*) also fourth and mean *terms* of a proportion can be found, and all geometric constructions which are made in Σ in plano, in this mode can be accomplished in F *apart from Axiom XI.*" The italics are Bolyai's, yet I find that they have not been reproduced in my published translation (the only one in English), nor in Frischauf's German, nor in Hoüel's French, nor in Fr. Schmidt's Latin text, nor in Suták's Magyar. Whitehead's researches will remind us all how great a thing it was to have reached the whole Euclidean system entirely apart from any parallel-postulate. It is a pleasure to be able to state that this was also done by Lobachévski. It is explicitly given in his first published work 'O nachalah geometri' (1829). 'Noviya nachala geometri' (1835), devotes to it Chapter VIII.

It is also at this point, so striking as pure mathematics, that general philosophy finds itself involved. Killing, Klein, and in general the German writers, distinctly draw back from any philosophical implications. The whole matter, however, has been opened in 'An Essay on the Foundations of Geometry,' by Hon. Bertrand A. W. Russell, Fellow of Trinity College, Cambridge (1897), who has had the good fortune to be the very first to set forth the philosophical importance of von Staudt's pure projective geometry, which in its foundation and dealing with the qualitative properties of space involves no reference to quantity. I discussed this point more than twenty years ago in the *Popular Science Monthly*, *à propos* of Spencer's classification of the Abstract Sciences.

In a note to the first edition of his classification of the sciences (omitted in the second edition), Spencer says, "I was ignorant of this as a separate division of mathematics, until it was described to me by Mr. Hirst. It was only when seeking to affiliate and define 'Descriptive Geometry' that I reached the conclusion that there is a negatively-quantitative mathematics as well as a positively-quantitative mathematics." As explanatory of what he wishes to mean by negatively-quantitative, we quote from his Table I.: "Laws of Relations, that are Quantitative (Mathematics), Negatively: the terms of the relations being definitely-related sets of positions in space, and the facts predicted being the absence of certain quantities ('Geometry of Position')." He also says: "In explanation of the term 'negatively-quantitative,' it will be sufficient to instance the proposition that certain three lines will meet in a point, as a negatively-quantitative proposition, since it asserts the absence of any quantity of space between their intersections. Similarly, the assertion that certain three points would always fall in a straight line is 'negatively-quantitative,' since the conception of a straight line implies the negation of any lateral quantity or deviation." But Sylvester has said of this very proposition

that it "refers solely to position, and neither invokes nor involves the idea of quantity or magnitude."

"Projective Geometry proper," says Russell, "does not employ the conception of magnitude."

Now it is in metrical properties alone that non-Euclidean and Euclidean spaces differ. The distinction between Euclidean and non-Euclidean geometries, so important in metrical investigations, disappears in projective geometry proper. Therefore projective geometry deals with a wider conception, a conception which includes both, and neglects the attributes in which they differ. This conception Mr. Russell calls 'a form of externality.' It follows that the assumptions of projective geometry must be the simplest expression of the indispensable requisites of all geometrical reasoning.

Any two points uniquely determine a line, *the straight*. But any two points and their straight are, in pure projective geometry, utterly indistinguishable from any other point pair and their straight. It is of the essence of *metric* geometry that two points shall completely determine a spatial *quantity, the sect* (German, strecke). If Mr. Russell had used for this fundamental spatial magnitude this name, or any name but 'distance,' his exposition would have gained wonderfully in clearness. It is a misfortune to use the already overworked and often misused word 'distance' as a confounding and confusing designation for a sect itself and also the measure of that sect, whether by superposition, ordinary ratio, indeterminate as depending on the choice of a unit; or by projective metrics, indeterminate as depending on the fixing of the two points to be taken as constant in the varying cross ratios.

That Mr. Russell's chapter 'A Short History of Metageometry,' contains all the stock errors in particularly irritating form, and some others peculiarly grotesque, I have pointed out in extenso, in SCIENCE, Vol. VI., pp. 478–491. Nevertheless the book is epoch-making. It finds "that projective geometry, which has no reference to quantity, is necessarily true of any form of externality. In metrical geometry is an empirical element, arising out of the alternatives of Euclidean and non-Euclidean space."

One of the most pleasing aspects of the universal permanent progress in all things non-Euclidean is the making accessible of the original masterpieces.

The marvellous '*Tentamen*' of Bolyai Farkas, as Appendix to which the 'Science Absolute' of Bolyai János appeared, a book so rare that except my own two copies, I know of no copy on the Western Continent, a book which has never been translated, a field which has lain fallow for sixty-five years, is now being re-issued in sumptuous quarto form by the Hungarian Academy of Sciences. The first volume appeared in 1897, edited, with sixty-three pages of notes in Latin, by König and Réthy of Budapest. Professor Réthy, whom I had the pleasure of meeting in Kolozsvár, tells me the second volume is in press, and he is working on it this summer.

Bolyai Farkas is the forerunner of Helmholtz, Riemann, Lie, though one would scarcely expect it from the poetic exaltation with which he begins his great work. "Lectori salutem! Scarce superficially imbued with the rudiments of first principles, of my own accord, without any other end, but led by internal thirst for truth, seeking its very fount, as yet a beardless youth, I laid the foundations of this 'Tentamen.'

"Only fundamental principles is it proposed here so to present, that Tyros, to whom it is not given to cross on light wings the abyss, and, pure spirits, glad of no original, to be borne up in airs scarce respirable, may, proceeding with firmer step, attain to the heights.

"You may have pronounced this a thankless task, since lofty genius, above the windings of the valleys, steps by the Alpine peaks; but truly everywhere are present gordian knots needing swords of giants. Nor for these was this written.

"Forsooth I wish the youth by my example warned, lest having attacked the labor of six thousand years, alone, they wear away life in seeking now what long ago was found. Gratefully learn first what predecessors teach, and after forethought build. Whatever of good comes, is antecedent term of an infinite series."

His analysis of space starts with the principle of continuity: spatium est quantitas, est continuum (p. 442). This Euclid had used unconsciously, or at least without specific mention; Riemann and Helmholtz consciously. Second comes what he calls the *axiom of congruence*, p. 444, § 3, "corpus idem in alio quoque loco videnti, quæstio succurrit: *num loca ejusdem diversa æqualia sint?* Intuitus ostendit, æqualia esse."

Riemann: "Setzt man voraus, dass die Körper unabhängig von Ort existieren, so ist das Krümmungsmass überall constant." See also the second hypothesis of Helmholtz.

Third, any point may be moved into any other; the free mobility of rigid bodies. If any point remains at rest any region in which it is may be moved about it in innumerable ways, and so that any point other than the one at rest may recur. If two points are fixed, motion is still possible in a specific way. Three fixed points not costraight prevent all motion (p. 446, § 5).

Thus we have the third assumption of Helmholtz, combined with his celebrated principle of Monodromy.

Bolyai Farkas deduces from these assumptions not only Euclid but the non-Euclidean systems of his son János, referring to the approximate measurements of astronomy as showing that the parallel postulate is not sufficiently in error to interfere with practice (p. 489). This is just what Riemann and Helmholtz afterward did, only by casting off also the assumption of the infinity of space they got also as a possibility for the universe an elliptic geometry, the existence of a case of which independently of parallels was first proven by Bolyai János when he proved spherics independent of Euclid's assumption. So if Sophus Lie had ever seen the 'Tentamen,' he might have called his great investigation the Bolyai-Farkas Space Problem instead of the Riemann-Helmholtz Space Problem.

The first volume of the 'Tentamen' as issued by the Hungarian Academy does not contain the famous appendix. But in 1897, Franz Schmidt, that heroic figure, ever the bridge between János and the world, issued at Budapest, the Latin text of the Science Absolute, with a biography of Bolyai János in Magyar, and a Magyar translation of the text by Suták József.

Strangely enough, though the Appendix had been translated into German, French, Italian, English, and even appeared in Japan, yet no Hungarian rendering had ever appeared. It was Franz Schmidt who placed the monument over the forgotten grave of János, only identified because there still lived a woman who had loved him. Now in this Magyar edition he rears a second monument. The introduction by Suták is particularly able.

The Russians have honored themselves by the great Lobachévski Prize; why does not that glorious race, the Magyars, do tardy justice to their own genius in a great Bolyai Prize?

One other noble thing the Hungarian Academy of Science has just achieved, the publication in splendid quarto form of the correspondence between Gauss and Bolyai Farkas: (Briefwechsel zwischen Carl Friedrich Gauss und Wolfgang Bolyai). It was again Franz Schmidt who, after long en-

deavors, at last obtained this correspondence from the Royal Society of Sciences at Göttingen, where Bolyai had sent the letters of Gauss at his death. The Correspondence is fitly edited by Schmidt and Staeckel. It gives us a romance of pure science. Gauss was the greater mathematician; Bolyai the nobler soul and truer friend. On April 10, 1816, Bolyai wrote to Gauss giving a detailed account of his son János, then fourteen years old; and unfolding a plan to send János in two years to Göttingen, to study under Gauss. He asks if Gauss will take János into his house, of course for the usual remuneration, and what János shall study meanwhile. Gauss never answered this beautiful and pregnant letter, and never wrote again for sixteen years! Had Gauss answered that letter Göttingen might now perhaps have to boast a greater than Gauss, for in sheer genius, in magnificent nerve, Bolyai János was unsurpassable, as absolute as his science of space. But instead, he joined the Austrian army, and the mighty genius which should have enriched the transactions of the greatest of learned societies with discovery after discovery in accelerating quickness, preyed instead upon itself, printing nothing but a brief two dozen pages.

Almost to accident the world owes the admirable volumes in which Staekel and Engel contribute such priceless treasures to the non-Euclidean geometry. An Italian Jesuit, P. Manganotti, discovered that one of his order, the Italian Jesuit Saccheri, had already in 1733 published a series of theorems which the world had been ascribing to Bolyai. Thereupon, in 1889, E. Beltrami published in the *Atti della Reale Accademia dei Lincei*, Serie 4, Vol. V., pp. 441–448, a note entitled 'Un Precursore italiano di Legendre e di Lobatschewski,' giving extracts from Saccheri's book which abundantly proved the claim of Manganotti.

In the same year, 1889, E. d'Ovidio, in the *Torino Atti*, XXIV., pp. 512–513, called attention to this note in another entitled, Cenno sulla Nota del prof. E. Beltrami: "Un Precursore, etc.," expressing the wish that P. Manganotti would by a more ample discussion rescue Saccheri's work from unmerited oblivion. Staeckel says the thought then came to him, whether Saccheri's work were not a link in a chain of evolution, the genesis of the non-Euclidean geometry.

In 1893, at the International Mathematical Congress at Chicago, in the discussion which followed my lecture, 'Some Salient Points in the History of Non-Euclidean and Hyper-Spaces,' wherein I gave an account of Saccheri with description of his book and extracts from it, Professor Klein, who had never before heard of Saccheri, and Professor Study, of Marburg, mentioned that there had recently been brought to light an old paper of Lambert's anticipating in points the non-Euclidean geometry, and named in connection therewith Dr. Staeckel. I at once wrote to him and published in the *Bulletin of the New York Math. Soc.*, Vol. III., pp. 79–80, 1893, a note on Lambert's non-Euclidean geometry, mentioning Staeckel's purpose to republish Lambert's paper in the Abhandlungen of the Leipziger Gesellschaft der Wissenschaften. But after this, in January, 1894, Staeckel formed the plan to make of Saccheri and Lambert a book, and associating with him his friend Friedrich Engel, they gave the world in 1895, 'Die Theorie der Parallellinien, eine Urkundensammlung zur Vorgeschichte der nichteuklidischen Geometric.' Strengthened by the universal success of this book, they planned two volumes in continuation. Staeckel takes the volume devoted to Bolyai János and his father. It is to begin with a more complete life of the two than has yet appeared, of course from material furnished largely by Franz Schmidt.

Then follows the 'Theoria parallelarum'

of Bolyai Farkas, interesting as proving that in 1804 Gauss was still under the spell of Euclid.

Then is to follow the Latin text of the immortal Appendix with a German translation. Next comes in German translation selections from the 'Tentamen.' The book concludes with the geometric part of 'Kurzer Grundriss,' the only one of the Bolyai's works printed originally in German. This volume is nearly published and may be expected in a few weeks. The volume undertaken by Engel has just appeared (1899). It is a German translation of Lobachévski's first published paper (18[illegible], 'On the Principles of Geometry,' and also of his greatest work, 'New Elements of Geometry, with Complete Theory of Parallels.' Only from the 'New Elements' can any adequate idea be obtained of the height, the breadth, the depth of Lobachévski's achievement in the new universe of his own creation.

Of equal importance is the fact that Engel's book gives to the world at last a complete, available text-book of non-Euclidean geometry. There is no other to compare with it.

For the history of non-Euclidean geometry we have the admirable Chapter X., of Loria's pregnant work, 'Il passato ed il presente delle principali teorie geometriche.' This chapter cites about 80 authors, mostly of writings devoted to non-Euclidean geometry.

In my own 'Bibliography of hyper-space and non-Euclidean geometry,' in the *American Journal of Mathematics* (1878), I gave 81 authors and 174 titles. This, when reprinted in the Collected Works of Lobachévski (Kazan, 1886), gives 124 authors and 272 titles.

Roberto Bonola has just given in the *Bollettino di Bibliografia e Storia della Scienze Matematiche* (1899), an exceedingly rich and valuable 'Bibliografia sui Fondamenti della Geometria in relazione alla Geometria Non-Euclidea,' in which he gives 353 titles.

This extraordinary output of human thought has henceforth to be reckoned with. Hereafter no one may neglect it who attempts to treat of fundamentals in geometry or philosophy.

GEORGE BRUCE HALSTED.

AUSTIN, TEXAS, Aug. 14, 1899.

BOTANY AT THE COLUMBUS MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SECTION 'G' was attended by a large number of Botanists and the meeting was in every way pleasurable and profitable.

On Monday afternoon Charles R. Barnes gave the vice-presidential address in Botanical Hall of the Ohio State University, to a large and appreciative audience. His theme was the 'Progress and Problems in Vegetable Physiology,' and the address has been published in full in SCIENCE.

During each of the succeeding four days, two sessions were held and thirty-three papers were read and discussed. Wednesday was made a Memorial Day to Sullivant and Lesquereux; the exercises are described below by Mrs. Britton.

Among the items of business transacted by Section 'G' may be mentioned that which related to the publication of the card index of American Botany, and an expression of high appreciation of the appointment of an eminent physiological chemist in the Division of Vegetable Pathology and Physiology, United States Department of Agriculture.

The authors of papers and an outline of the more important points are herewith presented:

'The Fertilization of Albugo bliti,' by F. L. Stevens, Chicago, Ill.

The paper presented the results of two year's research on the development of the

sex organs and the act of fertilization which, in this species, differs from the current conception of a fertilization in that the oösphere is a compound one, having about one hundred functional nuclei: each one of these fuses with one male pronucleus derived from the antheridium. The development of these nuclei and the organs that bear them is followed and the mitoses described, as is also the opening of the antheridial tube and the fusion of the nuclei. A new cell organ, present during the oögenesis, the *cænocentrum*, is described, and the ripening of the oöspore followed.

'The Embyro Sac of Leucocrinum montanum,' by Francis Ramaley, Boulder, Colorado.

The embryo sac of Leucocrinum is of the usual Liliaceous type. The sac is never greatly elongated but generally rather spherical. The polar nuclei fuse before the fecundation of the egg. The definitive nucleus moves from the center of the sac toward the posterior end before any division takes place. The synergids are large: they persist for a short time after the fecundation of the egg. The antipodal cells do not increase in number but a fragmentation of the nuclei sometimes occurs. The antipodals do not become completely disorganized for a long time, and may still be recognized after a considerable mass of endosperm has been built up and the sac completely filled. The author found nothing to suggest a fusion between the definitive nucleus and a male cell.

'Notes on Subterranean Organs,' by A. S. Hitchcock, Manhattan, Kansas.

A classification of the underground parts of perennial plants, especially the herbs, is made as below: accompanied also by notes and examples:

Roots which form adventitious buds;
Fleshy roots with a crown at apex:
Crown with top-root—with fibrous roots;
Rhizomes; simple, crown-bearing.

Various subdivisions of each of the above, with examples were given. The notes referred to plants in the vicinity of Manhattan, Kansas, confined chiefly to dicotyledons.

'Some Monstrosities in Spikelets of *Eragrostis* and *Setaria* with their Meaning,' by W. J. Beal, Agricultural College, Michigan.

A few plants of *Eragrostis major* made a second growth of some of the spikelets—more than twice the usual length, in a damp late autumn. A few spikes of *Setaria viridis* in same autumn had bristles bearing spikelets at the top, and one with a spikelet on the side of a bristle.

'Studies of the Vegetation of the High Nebraska Plains,' by Charles Edwin Bessey, Lincoln, Nebraska.

The physical conditions on the high plains of Western Nebraska include a general elevation of 1000 to 1200 meters above sea level, a rainfall of but 40 centimeters per year, a very high insulation, a sandy soil, with a generally undulating surface, with now and then a shallow moist valley. Until recently these plains were swept annually with prairie fires. The ecological conditions are taken up for the Box Butte plains where the grassy covering is an Agropyron-Stipa-Bouteloua formation; for the Snake Creek valley, with a Sporobolus formation, surrounded by a zone of Distichlis; for the undulating surface with its exclusive Carex formation; for rocky hills with a broad zone of Artemisia in one line capped with a zone of Mentzelia; for the river bottom (Platte) with its Distichlis-Atriplex-Chenopodium.

'The Tamarack Swamp in Ohio,' by A. D. Selby, Wooster, Ohio.

A preliminary study of the Larix plant company as occurring in Ohio. The location of these bogs in the northeast counties extending as far south as Canton, and in the extreme northwest of Ohio, was pointed out; and a preliminary list of 36 species collected

in these swamps by the author and E. W. Vickers, of Ellsworth, Ohio, was presented in summary form. The rarest of these are of the genera *Sarracenia, Drosera, Trientalis, Salix, Arethusa, Coptis, Chiogenes, Ilicioides, Cornus* (*C. Canadensis*) and species of *Vibúrnum*.

'The Breeding of Fruits for the Northwest Plains,' by Wm. Saunders, Ottawa, Canada.

The author refers to the many failures which have followed the testing of a large number of the hardiest forms of useful apples on the northwest plains. These failures have led to the belief that the most hopeful line of work in future is the improvement of two species of Wild Crabs from Northern Siberia, viz.: *Pyrus baccata* and *P. prunifolia*, both of which have been tested and found quite hardy, but are quite small. These have been crossed with hardy forms of the larger apples and some of the particulars of the results obtained from these crosses were presented.

'Field Experiments with 'Nitragin' and other Germ Fertilizers,' by Byron D. Halsted, New Brunswick.

The study of leguminous root tubercles is uppermost in the minds of botanists and there is a practical side that deeply interests the crop growers. It has been shown that the microscopic symbionts greatly assist in the acquiring of nitrogen by the plants with which they live.

Professors Knobbe and Hiltner, of Tharand, Saxony, foremost in the study of the symbiotic germs, have produced pure cultures and these are placed upon the market as bottled lymph under the trade name of 'Nitragin.' Experiments are now in progress at the New Jersey Experiment Station, and some of the results are as follows:

The germs from five species, namely, *Vicia sativa, V. villosa, Trifolium pratense, T. repens* and *T. incarnatum* were used, each in separate rows and upon the seeds of all five of the above named legumes. Plants were lifted August 3d and the tubercles counted upon five plants and the average taken. It was found that the tubercles were more numerous upon the check plants than where the 'Nitragin' had been used, and it seems evident, judging from the number of galls, that the germ fertilizer has had no appreciable effect.

A duplicate of the above trial was made upon soil where peas had been grown for four successive crops. Here the only difference to be noted was the large increase in the number of tubercles, those of the old pea land being nearly double those upon the new land.

A still more extended experiment was made with thirteen leguminous crops from land that had been variously treated in previous years with soil remedies for club root in turnips. It was found that sulphur and lime both materially diminished the number of tubercles.

An equal area was given to a test of the germ fertilizer offered through the trade under the name of 'Alinit' and recommended for crops generally. The actual weight of five leguminous crops and four cereals (one failed) showed a grand total in favor of the check, although the difference was only slight.

Experiments with several other substances that might be supposed to stimulate the development of germs in the soil indicate that they have no wholesome influence.

'The Duration of Bacterial Existence under Trial Environments,' by Henry L. Bolley, Agricultural College, N. D.

The paper is based upon studies made from ordinary cultures which had been preserved for a number of years. Many had been allowed to become air dried, suffering the varying conditions of the laboratory atmosphere. Other cultures had been hermetically sealed and thus kept in fresh form.

The results are of interest because of the longevity shown for many of the germs; and because of the indicated possibility of keeping typical cultures in normal form as to gross characters and as to the morphology of the individual germs for long periods of time.

'Suggestion for a more Satisfactory Classification of the Pleurocarpous Mosses,' by A. J. Grout, Brooklyn, N. Y.

It is axiomatic that the classification of plants having an alternation of generations should be based on both gametophyte and sporophyte character. Schimper and nearly all modern authors except Lindberg and Braithwaite give undue weight to sporophyte characters, as in the *Isothecieæ*, where a heterogeneous collection of plants is put in the same subfamily because of their sporophyte character alone. Lindberg while classifying more scientifically often overestimates single characters, *e. g.*, when he puts *Porotrichum* (*Thamnium*) with the Neckeraceæ because of its leaf character, all its other characters indicating a close relationship to the Hypneæ.

There are two characters of the pleurocarpous mosses whose importance in classification is generally underestimated: the presence or absence of a central strand in the stem and, the presence and degree of development of fine transverse lines on the lower dorsal plates of the teeth of the peristome. The latter are present and well developed in the subfamilies Hypneæ and Brachytheciæ. Also in the genera *Isothecium*, *Porotrichum*, *Pterogonium* and *Leseura*, which are closely related and constitute a separate subfamily differing from the above mentioned subfamilies in leaf structure.

These lines are as well developed in Thuidium and allied genera of the Leskeaceæ (as usually constituted) as in the Hypneæ and taken in connection with the perfect Hypnaceous peristome indicates that these forms are at least as closely related to the Hypneæ as to the Leskeaceæ. In the latter family these lines are vestigial and the whole peristome degenerate so that Thuidium must either be an intermediate form or a separate derivative from the Hypnaceous type. The presence of a perfect peristome with these lines well developed in the Pterygophyllaceæ indicates that this family is closely related to the Hypneæ.

The entire absence of these lines in the Fontinalaceæ, Neckeraceæ, and Climacium taken in connection with other characters indicates that these forms constitute a group by themselves, coördinate with the forms previously mentioned and possibly derived independently from the acrocarpous mosses. The anomalies of the Fabroniaceæ may possibly indicate a third similar group.

The central strand is the physiological homologue of the vascular bundle and for many reasons would seem to be of a far more important character than the length and shape of the capsule, yet in our present system it is given far less weight. The presence of a central strand is usually correlated with the presence of a costa in the leaves except in aquatic or subaquatic species. This indicates that *Amblystegium* and *Plagiothecium* are not naturally grouped and must also modify the present systems in many cases.

The author wishes it distinctly understood that the above statements are thrown out as suggestions, because his knowledge of forms is far too incomplete to warrant any final statements.

'Notes Concerning the Study of Lichen Distribution in the Upper Mississippi Valley,' by Bruce Fink, Fayette, Iowa.

A brief report of area covered, data as to habitat, etc., and a list of species examined. The author pointed out the incompleteness of recorded observations and suggested the noting of fuller data in connection with the collection of specimens.

'Botanical Teaching in Secondary Schools.'

Under this head three papers were read, the authors being W. C. Stevens, Lawrence, Kansas; Ida Clendenin, Brooklyn High School, and Conway MacMillan, Minneapolis, Minn.

The paper of Mr. Stevens forcibly pointed out serious defects in much of the so-called botanical teaching, and argued for a study of plants rather than text-books merely.

Miss Clendenin maintained that biological studies were important factors in mental development of children, and that they should not be postponed till late in the school curricula. It was immaterial whether zoology or botany was taken up first, but that at least an entire school year—four or five lessons weekly—should be given to them. In addition to this the last year in the course should offer one or both of these branches as optional studies. As to whether the work should be largely microscopical, dealing fully with the cell and tissues, commencing with the lowest plants and closing with the representatives of the highest groups; or rather making morphology and physiology prominent in the course, dealing mostly with specimens and material obtainable by the pupils and using the microscope only for demonstration; is determined mainly by the environments in which the teacher finds himself (large classes, excessive work in the school room, etc.): there is no alternative for the great majority, and the second scheme must be followed.

Miss Clendenin rightly insisted that it offered as good disciplinary and practical work as the first, and that the finer methods of the modern laboratory of histology should be left to the Universities, where alone their practice was possible.

Professor MacMillan's paper can not be condensed and therefore, it is here presented as it was read to the Section:

I.

Introduction:

(*a*) Education is essentially a social function, hence the school is a social organ. The work of the school must therefore be criticised not by the individual aptitude or abilities of the graduates, but by the intellectual and moral condition of the community in which the school has been active.

Sociology, not psychology, is the scientific foundation of a true system of pedagogics.

(*b*) Society is an organism with moving equilibrium, always progressive or decadent. Progress of individuals is not incompatible with social retrogression.

It is stated that homicides are on the increase in the United States. In the light of the figures it may well be asked, does education educate?

(*c*) What are the fundamental difficulties with the schools? clearly the same as with any complex organ derived by a process of evolution: *There are too many vestigial characters.*

Educational methods arise to meet the exigencies of particular epochs, nations or localities. After these epochs are past, nations extinct or localities abandoned, the methods do not likewise disappear but remain petrified in the traditions of the schools, to be worn away by the slow attrition of the ages.

Nevertheless, while I am in favor of educational museums, I regret that our public schools should ever be such institutions.

(*d*) The modern tendency in school cirricula is to introduce everything new as a concession to the radicals, and to keep everything old as a concession to the conservatives. But education is not pursued by the race either for the exploitation of pedagogical theories, or for the perpetuation of traditions belonging to a by-gone civilization.

The real practical problem is not what to put into the cirriculum, but what to take out. This deserves the most thoughtful consideration. We are sometimes told that

there are so many demands upon the high school pupil that little space is left for biological science.

II.

(*a*) The object of the high school education is not culture but *capability*, not individuality but *organizability*, not consciousness but *conscientiousness*, not well-rounded men and women but *well-adjusted* men and women.

Therefore, education must always have a double content (1) information, developing the structure of the social individual, (2) training exercise in social functioning.

(*b*) A general classification may be made of subjects in the cirriculum, under these views.

1. Technique of life: Reading, writing, spelling, mathematical calculation, etiquette, hygiene, manual training and drawing, local geography, modern languages, logic.

2. Conditions of life: Chemistry, physics, physiography, geology, civil government. (Physiology.)

3. Principles of life: Psychology, economics, ethics, sociology.

4. Epitomes of life: History, biology, literature, art, music.

5. Vestigial subjects: Ancient languages, metaphysics.

(*c*) Such a classification is necessarily very elastic. Certain phases of biology are seen to be properly included under each of the classifications.

(*d*) In general the value of biological instruction lies not in the information, but in the training. This training is without a rival in the curriculum for the following reasons:

1. The organisms studied, whether plants or animals, are microcosms revealing to the student, under conditions free from prejudice, the laws and factors of man and of society.

2. As compared with history or literature which are likewise epitomes of life, biology has the advantage of thorough organization under the modern scientific method. The subject itself may be considered as a record: it differs, however, from history in being a record not so much impregnated with human error, and from literature in being free from the personal element. Furthermore, the method of reading the record is fresh, and devoid of those older unscientific blemishes which prevent us from interpreting either history or literature apart from prejudice.

3. The quality of insight is developed under conditions that are more impartial than in the study of history or literature. For example, there is a secular and even a profane history—but there is neither secular or profane biology. There is national, religious, political, personal literature, but there is no national, no religious, no political, no personal biology.

4. The quality of judgment, under such conditions, must be more perfectly and completely developed than under any other.

Observation, classification, recollection, orderly notation, etc., can be inculcated as well by other disciplines. Note A. T. Harris' comparison of botany with grammar.

III.

What should be the nature of High School courses in Biology.

(*a*) In the first place courses in elementary general biology are impracticable because (1) either an inherently superficial view of both plants and animals, or (2) a one-sided view of the living world must be presented. Further, there is no possible way of instituting just comparisons between plants and animals in the time given to elementary study. Consequently, the idea of 'general biology courses' is founded on pedagogical error.

(*b*) Courses must be in 'botany and zoology,' or 'botany or zoology.'

(*c*) A year of either biological science should include more anatomy and physiology than taxonomy, although the latter must not be neglected.

(*d*) I favor a year of botany followed by a year of zoology, in the High School course.

IV.

Methods: (Not presented).

'On the Occurrence of the Black Rot of Cabbage in Europe,' by H. A. Harding, Geneva, N. Y.

During the season of 1898 this disease was observed by the author, on cabbage and related plants in fields near Haarlem in Holland, Bonn, Karlsrule, Fulda, Berlin, Halle on Saale and Kiel in Germany, Slagelse in Denmark, Zurich in Switzerland and Versailles in France.

Wherever an opportunity to visit fields presented itself the disease was always found, although with the exception of Switzerland and possibly Denmark, it did not appear to be of economic importance.

Field observations were supplemented whenever possible by microscopic and cultural examinations.

Sections of infested plant parts presented the same characters as is shown by the disease common in America.

Cultures uniformly produced a predominant growth of yellow colonies, agreeing in general appearance and in morphology with *B. campestris* Pam.

Subcultures were brought to New York and inoculated into cabbage and cauliflower. In the case of germs obtained from Zurich, Switzerland, the inoculation invariably produced a disease exactly like that found common in our fields, and behaved in all respects like cultures obtained from diseased plants in Wisconsin and New York.

With germs brought from other plants in Europe the results were not so conclusive.

'A Thousand Miles for a Fern,' by Charles Edwin Bessey.

The Southern Maiden-hair Fern (*Adiantum capillus-veneris*) was found August 24, 1898, in the Black Hills of South Dakota. It grows in the warm streams (25° C.), which issue from numerous large springs. The species is indigenous.

'A Summary of our Knowledge of the Fig with Recent Observations,' by Walter T. Swingle, Washington, D. C.

A summary of the existing knowledge concerning the fig, caprifig and caprification, including the results of recent observations by the author in North Africa, Greece and Asia Minor.

This paper is published in full below.

'The Classification of Botanical Publications,' by William Trelease, St. Louis, Mo.

This article will appear in full in a later number.

'The Geotropism of the Hypocotyl of *Cucurbita*,' by Edwin Bingham Copeland.

Experiments show that the plant executes the geotropic response without direct regard to the consequences, and without the power of adaption to unusual conditions. In nature the rapid growth of the under side of a prostrate hypocotyl bears the cotyledons upward: but if a young plant be placed horizontal with the cotyledons fast and the roots free, the same response bears the roots upward, and is therefore likely to be immediately fatal. While the object of geotropism is to secure a certain arrangement of the longitudinal elements for the plant—root, hypocotyl, cotyledons—the stimulus is a disturbance of the normal disposition of the transverse pressure of the tissues. It is not necessary for the perception of a geotropic stimulus that the plant compare the difference in position or pressure of its two halves; for if the plant is laid prostrate, the lower half will of itself grow more rapidly than the upper, as may be demonstrated by cutting the halves entirely apart.

'The Destruction of Chlorophyll by Oxidizing Enzymes,' by A. F. Woods, Washington, D. C.

This paper details the results of experiments going to show that the Mosaic disease of tobacco is due to oxidizing enzymes rather than to a 'living fluid contagium' as suggested by Beijerinck. It also shows that these enzymes are unusually abundant in many other cases of variegation, and in the disease known as peach yellows and peach rosette; and in these cases also ascribes the destruction of the chlorophyll to the abnormal abundance of these ferments.

'The Effect of Hydrocyanic Acid Gas upon the Germination of Seeds,' by C. O. Townsend, College Park, Md.

In the experiments that form the basis of this paper, seeds in both the dry and damp state have been tested with different strength of gas and for different periods of time. In the case of dry grains and seeds it was found that they might remain for several weeks in an atmosphere of hydrocyanic acid gas, many times as strong as is required for the almost instantaneous destruction of insect life, without appreciably injuring their germinating power. Indeed the gas under these conditions slightly accelerates germination, and the subsequent rate of growth of the seedlings is slightly above the normal.

Seeds that have been soaked in water become very sensitive to the presence of hydrocyanic acid gas. If the seeds have been soaked for twenty-four hours they cannot germinate if more than 0.030 of a grain of potassium-cyanide per cubic foot is used in generating the gas. Even 0.003 of a grain of potassium-cyanide per cubic foot has a very marked effect on the time of germination of seeds that have been soaked in water for twenty-four hours. If the grains and seeds have been soaked but six hours, they are more resistant than when soaked for a longer period; but even under these circumstances germination is distinctly retarded by the pressure of hydrocynic acid gas.

'Some Physiological Effects of Hydrocyanic Acid Gas Upon Plants,' by W. G. Johnson, College Park, Md.

A brief report of the first precise experiments with hydrocyanic acid gas upon young fruit trees, both dormant and in full foliage.

'Etiolative Reactions of Sarracenia and Oxalis,' by Wm. B. Stewart, Minneapolis, Minn.

An anatomical examination of etiolated leaves of Sarracenia and Oxalis, shows the increase of length of supporting tissues by increase in size and multiplication of cells, and the new development of portions which functionate in light only.

Etiolative reactions are almost purely adaptive in their nature.

'The Mycorhiza of Tipularia,' by Julia B. Clifford, Minneapolis, Minn.

The roots tipularia show some marked specializations of structure for adjustment, for the presence of an endotropic fungus with which a symbiosis is formed. The fungus is differentiated into a vegetative mycelium, with external absorbent branches and internal branches serving as organs of interchange.

'Cultures of Uredineæ in 1899,' J. C. Arthur, Lafayette, Ind.

Successful cultures of eleven species of Uredineæ were made upon their host plants, showing the connection of æcidial and teleutosporic stages. The following is a list of the associated forms, the host plants, and nature of the cultures:

1. *Puccinia Convolvulus* Cast. on *Convolvulus sepium*, and *Æcidium Calystegiae* Desm. on same host, with sowings of teleutospores.

2. *Puccinia Phragmitis* (Schum.) Koern. on *Phragmites communis* Trin. and *Æcidium rubellum* Pers. on *Rumex crispus* L. and *R. obtusifolius* L. with sowings of teleutospores.

3. *Puccinia Americana* Lagh. on *Andropogon sco-*

parius Mx. and *Æcidium Pentstemonis* Schw. on *Pentstemon pubescens* Sol. with sowings of æcidiospores and teleutospores.

4. *Puccinia Windsoriæ* Schw. on *Triodia cuprea* Jacq. and *Æcidium Pteleæ* B. & C. on *Ptelea trifoliata* L. with sowings of æcidiospores.

5. *Puccininia Vilfæ* A. & H. on *Sporobolus asper* (Mx.) Kunth. and *Æcidium verbenicola* K. & S., with sowings of æcidiospores.

6. *Puccinia peridermiospora* (E. & T.) Arth. on *Spartina cynosuroides* (L.) Willd, and *Æcidium Fraxini* Schw. on *Fraxinus viridis* Mx. with sowings of teleutospores.

7. *Puccinia Caricis* (Schum.) Reb. on *Carex stricta* Lam. and *Æcidium Urticæ* Schum. on *Urtica gracilis* Ait., with sowings of æcidiospores.

8. *Puccinia angustata* Ph. on *Scirpus atrovirens* Muhl. and *Æcidium Lycopi* Ger. on *Lycopus sinuatus* Ell., with sowings of æcidiospores.

9. *Uromyces Euphorbiæ* C. & P. on *Euphorbia nutans* Lag. and *Æcidium Euphorbiæ* Am. Auct. on same host, with sowings of æcidiospores.

10. *Phragmidium speciosum* Fr. on *Rosa humilis* Marsh. and *Cæoma miniata* Am. Auct. on *Rosa sp.* with sowings of teleutospores.

11. *Triphragmium Ulmariæ*—on *Ulmaria rubra* Hill and *Cæoma Ulmariæ*—on same host, with sowings of æcidiospores and uredospores.

'The Embryology of Vaillantia Hispida,' by Francis E. Lloyd, New York.

The archesporium consists of about twelve cells. But one of the megaspores produced therefrom normally becomes the embryo-sac, the development of which follows in much the usual fashion, in a position, however, removed from the archesporium; this position is attained by a migration of the megaspore involved out of the nucellus into the micropylar canal. Fusion of the polar nuclei takes place at some distance from the egg; toward which, however, the endosperm moves and to which it ultimately becomes closely applied. The antipodals are three, one of which is very long, one end being plunged into the disintegrating archesporium, which is believed to serve as food. The embryo has a suspensor which forms outgrowths into the endosperm, these acting as food absorbing organs. The endosperm enlarges at the expense of the integument which has the appearance of a tissue undergoing digestion. A part of the integument remains as a seed envelope. The reserve food consists of cellulose and starch.

'The Division of the Megaspore of Erythronium,' by John H. Schaffner, Columbus, Ohio.

Our knowledge of the process of reduction is still very fragmentary and the observations and interpretations presented by the several investigators differ widely. *Erythronium albidum* and *E. americanum* present favorable objects for the study of the important phenomena which take place during the transition from the sporophyte to the gametophyte. As in the case of the lilies generally, the megaspore of *Erythronium* arises from the archesporial cell, directly, by differentiation and not by division. The archesporial cell can usually be distinguished before the first of October and it continues to develop until after the first of December, when it passes into a partial resting stage and does not complete its division until early the next Spring. The cell, therefore, in which the reduction takes place, has a period of development extending over six months.

In the Fall while the nucleus is expanding, the chromatin net-work begins to thicken until a continuous band is formed. In the Spring the band twists itself up into twelve loops, which break apart and form twelve very large, coiled chromosomes. The chromatin granules never appear very distinct and they do not begin to divide until the chromatin band begins to form the loops. After the pseudo-reduction the chromosomes are arranged on the spindle threads with their closed ends turned outward and are then gradually untwisted and pulled apart at the middle. This results in the transverse division of each chromosome, one transverse half going to each daughter nucleus.

The division of the megaspore of *Ery-*

thronium is, therefore, essentially the same as in *Lilium philadelphicum*, and it seems to the writer that a transverse, qualitative division is the only interpretation possible.

'The Flora of Franklin County, Ohio,' by A. D. Selby, Wooster, Ohio.

A comparison of the known flora of Columbus, Ohio, with that listed in the catalogue of Wm. S. Sullivant in 1840, in tabular form. It shows a gain of the known list amounting to 353 species; of which 117 are introduced; in other words, 184 species of the present known flora, or 167 per cent. of the present, are of introduced species.

'The Fungus Infestation of Agricultural Soils in the United States,' by Erwin F. Smith, Washington, D. C.

A continuation of studies begun by the writer in 1894 on the parasitic soil *Fusaria* of the United States. Results are detailed of completed experiments on soil infections with the watermelon fungus, over 500 of which have been obtained. It shows that related species are likely to prove equally destructive to plants of other families, *e. g.*, cabbage, tomato, sweetpotato. The fact to be specially emphasized is that these fungi live in the soil over winter and attack the plant from the earth. Further, the soil once infected with one of these resistant fungi becomes worthless for growing the agricultural plants subject to it for a long series of years, and consequently the greatest care should be taken to avoid the spread of these parasites to land which is now free from them.

'Are the Trees Advancing or Retreating Upon the Nebraska Plains'? by Charles Ewing Bessey.

To appear in full later.

'Useful Trees and Shrubs for the Northwest Plains of Canada,' by Wm. Saunders, Ottawa, Canada.

In this paper is given the results of a large number of experiments conducted during the past eleven years in testing the hardiness and usefulness of many species and varieties of trees and shrubs, both native and foreign, on the Canadian experimental farms in Manitoba and the northwest territories. Some particulars are given as to the success which has attended this work and attention called to some of the groups to which the hardiest forms belong. References are also made to many individual species and varieties which have been found most useful.

'The Occurrence of Calcium Oxalate and Lignin during the Differentiation of the Buds of *Prunus Americana*,' by H. L. Bolley and L. R. Waldron, Agricultural College, N. D.

The paper consists of a short *résumé* of the occurrences of crystals of calcium oxalate and of the presence of lignified tissues, as observed by Mr. Lawrence Waldron in a study conducted upon the development of life history of the buds of *Prunus Americana*. It was found that the crystals of calcium oxalate occur in quite surprising abundance in the meristematic tissues of the bud and in the very youngest stages of the scales of the bud; and that the oxalate becomes lessened in proportionate quantity as the tissues develop. Lignification of the hairs and scales of the bud commences at a very early period of their development. While it is usually assumed that calcium oxalate is a waste product of metabolism, its occurrence in such large quantities in the meristematic cells of the bud and scales would seem to indicate a question as to whether it has a definite value at this point, at this particular time, in the life history of the plant.

'Two Diseases of *Juniperus*,' by Herman Von Schrenk, St. Louis, Mo.

The species of *Juniperus* are trees which have few fungous and insect enemies. The author describes two destructive diseases of *Juniperus Virginiana*, one of which is also found in *Juniperus Bermudiana* and *Thuya*

occidentalis. The first one is due to an undescribed species of *Polyporus*. Large holes are formed in the heartwood of the trunk, one above the other. Each is full of mycelium and has a thick white lining, consisting of wood fibers from which the lignin has been removed, leaving the pure cellulose. The fruiting part forms on the outside of the trunk, forming around a dead branch. It has been reported so far from Kentucky and Tennessee. The second form of destruction is more widely spread. It is due to a *Polyporus*, probably *P. carneus*. Long pockets are formed in the heartwood of a tree, filled with a brown bitter wood, which has characteristic properties. The sporophore forms in the branch holes on the trunk; they have a flesh-colored hymenium and are quite common.

Attention is called to the fact that a very large per cent. of the individuals of *Juniperus Virginiana* are defective because of one or other of these fungi.

'The Crystals in *Datura Stramonium* L.', by Henry Kraemer, Philadelphia.

An exhaustive paper which will be published in full in the *Journal of Pharmacy*.

W. A. KELLERMAN,
Secretary of Section G.
OHIO STATE UNIVERSITY.

SULLIVANT DAY.

WEDNESDAY, August 23d, was taken by the Botanical Section for a bryological memorial to do honor to Sullivant and Lesquereux. The meeting was held in the Botanical Lecture Room which had been appropriately decorated with mosses and ferns and hung with portraits of Sullivant and Lesquereux loaned by the members of both families present. The tables surrounding the room were filled with books and pamphlets on bryological subjects, and the spaces under the windows with microscopes showing rare or type specimens of mosses and hepatics. The walls were hung with photographs of botanists whose names are associated with American bryophytes, as well as plates and illustrations from original publications.

The meeting was called to order with Dr. Chas. R. Barnes in the chair and Professor Kellerman as Secretary, who welcomed the large number of members and guests present and opened the session with some preliminary remarks on the work done on the flora of Ohio by Joseph Sullivant, William S. Sullivant, Riddell and others, and exhibited pressed specimens, framed of *Sullivantia Ohionis*, *Lonicera Sullivantii*, *Solidago Ohionis*, *S. Riddellii*, and other rare plants. Duplicates of these were distributed in sets after the adjournment of the session. Professor Kellerman then read Dr. Gray's tribute to Sullivant from the Supplement to the Icones. Twelve North American mosses have been named for Sullivant; specimens of these with original drawings were loaned from the Sullivant collection in the Gray Herbarium at Harvard University; duplicates of these species were presented by the Herbarium of Columbia University to the Ohio State University and microscopic slides were made by Mrs. Britton who gave a short account of them.

Dr. Barnes then read a brief biographical sketch of Leo Lesquereux, exhibiting the picture of his father's home at Fluellen where he fell down a mountain in search of plants, one of the causes of his subsequent deafness, a misfortune which in the end proved a blessing, as it enabled him to devote himself with undisturbed serenity to the study of fossil plants and mosses. Several of his paleontological works were not published until after his death and many of the illustrations were made by his granddaughter, Miss Ahrhart, who acted as his interpreter and assistant. A brief account of these posthumous publications was pre-

pared by Dr. Arthur Hollick, and presented by Professor D. T. MacDougal.

Mrs. Britton gave a chronological record of the study of N. A. bryophytes since 1850, with tabulated lists of publications and exsiccatæ, illustrating more particularly with books and pamphlets the progress of the study of the mosses since the publication of Lesquereux' and James' Manual in 1884. Professor Kellerman showed a collection of mosses formerly the property of A. Schrader who made the drawings for Sullivant's Icones. Most of the specimens are European, collected or presented by Lesquereux, but there a few duplicate types of North American species accompanied by plates, among them the originals of Sullivant's species from the Survey of the 35th parallel. The collection was presented to the Ohio State University by Dr. Townshend.

Professor Underwood gave a brief account of the progress of the study of the Hepaticæ, exhibiting his own publications and those of W. H. Pearson, A. W. Evans and M. A. Howe, and a set of plates from the last volume of the Memoirs of the Torrey Botanical Club, containing the enumeration of Californian Hepaticæ and Anthocerotaceæ. Twelve new species were figured by Dr. Howe, the originals of which were exhibited for him by Professor F. E. Lloyd, who commended the morphological value of his work.

An attempt was made to secure reports from all North American bryologists. This was only partially successful, as many were away and unable to be present. Dr. Barnes showed a set of the publications of Renauld and Cardot from the *Botanical Gazette* and of Roll from Hedwigia. Dr. George N. Best sent a set of his reprints and an abstract of his work. Dr. A. J. Grout sent a set of the Bryologist and his Revisions of some genera of pleurocarpous mosses with suggestions for a more satisfactory classification. Dr. Charles Mohr sent some notes on the moss-flora of Alabama, which were read by Professor F. S. Earle. Mrs. Britton exhibited a set of maps with regions marked where mosses have been collected, and lists of stations and collectors, compiled with the assistance of Dr. J. K. Small. Reports were received from the Sullivant Moss Chapter through its secretary, Mrs. Annie M. Smith, with a list of members and of the mosses named by Sullivant. The Philadelphia moss-chapter also made a report through its secretary, Mr. Mc. Elwee, with lists of the collections and publications available for studying the mosses at the Philadelphia Academy of Natural Sciences.

At the conclusion of the exercises, Dr. C. E. Bessey spoke of the desirability of founding a bryological scholarship to be named for William S. Sullivant. This proposition was heartily commended by the chairman and the various members of the Sullivant family present. During the remainder of the day the exhibits were open to inspection and duplicate specimens of *Orthotrichum Ohioense* were distributed.

Elizabeth G. Britton.

SECTION D (ZOOLOGY) AT THE DOVER MEETING OF THE BRITISH ASSOCIATION.

The president of this Section was Mr. Adam Sedgwick, of Cambridge, and his address dealt with such fundamental questions as reproduction, variation and heredity. He considers that one of the most important results of the evolutionary change has been the gradual increase and perfection of heredity as a function of organisms and a gradual elimination of variability. This would enable evolution to be effected much more rapidly in early periods than at present, and so may enable us to bring our requirements as to time within the limits granted by the physicists.

As some of the other Sections were to receive addresses of general biological interest,

it was arranged that Section D should adjourn after Mr. Sedgwick's address until the following morning. The scheme of work for the remaining days was this: Friday morning, morphological papers; Friday afternoon, entomology and some reports; Saturday, marine biology and reports; Monday, morphology, embryology, etc.; Tuesday, sea-fishery papers and discussions.

Amongst the morphological papers on Friday were:

1. Mr. J. Lister (Cambridge), 'On *Astrosclera willeyana*,' the type of a new family of Calcareous sponges. This remarkable new form was collected by Dr. A. Willey in the Loyalty Islands. Its abundant calcareous polyhedral spicules fuse to form a continuous branched skeleton. The ciliated chambers in the canal system are very minute, and the ciliated cells have no collars round the flagella.

2. Professor S. Symington (Belfast), 'On the Morphology of the Cartilage of the Monotreme Larynx.' The author considers that both the ontogeny and phylogeny of the mammalian epiglottis support the view that it is a single median structure, and not as Gegenbaur supposed the result of fusion of two lateral elements.

3. N. Bishop Harman (Cambridge), 'The Palpebral and Oculomotor Apparatus in Fishes.' Seventy species were examined. The degree of complexity was not found to agree with the probable phylogeny, or with the scheme of classification. The source of the complex musculature of the eyelids of Selachii was traced to the branchial musculature of the spiracle, and this was also exemplified by the inverse ratio existing between the condition of the spiracle and the nictitating membrane. In those fish in which the latter shows its highest development the spiracle is absent and *vice versa*.

The condition of the orbital sac of a supporting rod of cartilage in the eyes of many cartilaginous fishes, of the ligament in relation to the optic nerve in many bony fishes, and of the eye muscles and other neighboring structures, was discussed in the various groups and some species of fishes. The special condition of the obliquus superior in pleuronectids and in some mammals indicates the possibility of independent evolution of organs in widely severed types along similar lines when the conditions of use are similar. This paper will be published *in extenso* in the *Journal of Anatomy and Physiology*.

4. Several minor papers and reports were also taken.

On Saturday, when some of the zoologists from the French Association, then meeting at Boulogne, visited the Section, a few papers on Marine Biology likely to prove interesting for joint discussion were read. Mr. W. Garstang gave a report upon his periodic investigation of the plankton and physical conditions of the English Channel during 1899. They were carried out at quarterly intervals from a steamer along certain fixed lines from Plymouth to Ushant, then out to the 100 fathom line, and back to Plymouth across the mouth of English Channel. Serial observations were taken of the water temperatures of the salinity and of the contained fauna and flora. At first the plankton was collected by means of a pump and hose, but this proved unsatisfactory, and so Mr. Garstang devised a closing townet which is a modification and signification of Giesbrecht's. This new net and also that of Dr. C. G. Joh. Petersen, of Copenhagen, were on exhibition in the Section, and were also shown working in the sea to a party of zoologists on board Mr. Woodall's yacht one afternoon during the meeting. In the discussion that followed, Baron Jules de Guerne discussed the somewhat similar net he had been using on board the Prince of Monaco's yacht, *Princesse Alice*.

Reports upon the work done by holders

of the British Association tables at the Naples and Plymouth biological stations were then submitted.

On Monday the chief papers were:

1. J. S. Kerr, 'The Development of *Lepidosiren paradoxa*,' and a note on the hypothesis of the origin of the vertebrate paired limbs.

2. J. F. Gemmill, 'On Negative Evidence regarding the Influence of Nutrition in Determining Sex.' Dr. Gemmill deals with marine animals fixed in such a position that some individuals get more food than others. This seems to cause no difference in the proportions between the sexes.

3. F. P. Morena and A. Smith Woodward, 'Exhibition of Skull of Extinct Chelonian *Miolania*, and of newly-discovered *Neomylodon* remains from Patagonia,' with remarks.

4. G. E. H. Barrett Hamilton, 'The Fur Seals of Behring Sea.'

On Tuesday Sir John Murray read a paper on Dr. Petersen's experiments on plaice culture in the Limfjord, Denmark. Outside the fjord the plaice are found abundant, but small. When transplanted into the richer feeding ground they rapidly grow larger, and can be sold at such a price that it may be regarded as successful economic fish culture.

Mr. W. Garstang then gave an account of his experiments at Plymouth in rearing young sea-fish. He has used the Butterfly Blenny, kept in 'plunger' jars, not more than five larvæ to a gallon of water, and fed on plankton. The experiments have been very successful, about 50% of the larvæ being reared through the metamorphosis to young adults. Professor McIntosh finally had a paper on the occurrence of the grey gurnard (*Trigla gurnardus*) and its spawning in shore and off shore waters. He shows by a monthly examination of the statistics that this important fish does not begin to migrate in shore for spawning purposes until March, and attains its maximum in May. He does not consider that there is a second spawning migration later (August), as stated by the Fishing Board for Scotland. The spawning extends from April to September.

The reports of the committees to the sections were:

1. Naples Zoological Station, with report by Dr. Jameson on his work at Cephyrea.

2. Plymouth Biological Station, with papers on the embryology of *Polyzoa*, by T. H. Taylor, and on rearing of *Echinid* larvæ, by Professor MacBride.

3. Zoology and Botany of West India Islands, Final Report, with list of publications.

4. Zoology of Sandwich Islands, Exploration and publication both in progress.

5. Bird Migration in Great Britain and Ireland, Records now being worked out.

6. Zoological and Botanical Publication, Committee on Correspondence with Editors.

7. Index Animalium, First section (1758–1800) nearly ready for publication.

8. Pedigree Stock Records, Reliable Records by Photography of Pedigree Stock.

9. Circulatory Apparatus for Marine Organisms, Record of Color Changes in Crustacea.

Most of these committees were reappointed, with grants, for the coming year.

W. A. Herdman.

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*THE DIŒCISM OF THE FIG IN ITS BEARING UPON CAPRIFICATION.**

As is well known, the edible fruit of the fig is morphologically an enlarged, hollow, flowering branch, bearing within the nearly closed cavity thousands of minute flowers. It is therefore not a true fruit in a botanical sense, but a fleshy receptacle.

Two crops of figs are usually produced during the year; first, the *figues fleurs*, or *brebas*, which appear in March or April,

*Read before Section G of the American Association for the Advancement of Science at Columbus.

and the ordinary figs, appearing on the new wood of the year, after the *brebas* mature, in June or July, and ripening in August or September. This second crop may be irregular in season, some Italian sorts not maturing all their fruits until Christmas (the 'Natalino') or Easter (the 'Pasquale'). In both crops of figs the flowers are exclusively female, though always malformed in the *brebas*, according to Gasparrini and Solms-Laubach, and sometimes in the second generation, according to Dr. Eisen. The flowers in the *brebas* are never pollinated, and indeed no pollen is to be had at the season when they develop. The ordinary figs may be fecundated by pollen from the caprifig, and the sorts which produce the dried figs of commerce are regularly so pollinated by the fig insect (*Blastophaga*), and in consequence yield fertile seeds in abundance. These figs of the so-called Smyrna type often absolutely require pollination in order to set a crop while the ordinary sorts esteemed for eating in the fresh condition develop without the inclosed flowers having been pollinated, but lack the peculiar nutty flavor communicated to the dried fig by the presence of the fertile seeds, a fact to which attention was first called by Dr. Eisen.

THE CAPRIFIG.

The caprifig is even more complicated in its fruiting than is the ordinary fig. There are three generations of fruits, usually known by their Neapolitan names. I. The *mamme*, or caprifigs of the winter generation, which set about October and ripen from March to May, usually in April. II. The spring generation, called *profichi*, setting when the *mamme* fall, and ripening in June or July. This is the generation for caprification. III. The summer generation, *mammoni*, which set shortly after the *profichi* fall and ripen when the *mamme* set. All three generations harbor the fig insect, *Blastophaga psenes*,* which lives inside the ovaries, converting the seed into a gall. When the female insects enter the young caprifigs after leaving the ripe caprifigs of the previous generation, they lay one egg in each of the gall flowers, which are then very like female flowers but not identical, having imperfect stigmas. The *profichi* or spring generation caprifigs bear abundant male flowers in a zone occupying the upper part of the fig, just below the mouth. It is this generation, abounding in pollen, which is used in caprification. It is worthy of note that male flowers mature *nearly two months* after the gall flowers are ready to receive the eggs of the insect, and only just before the figs ripen; *e. g.*, *mammoni* female flowers, which occur though rarely, are pollinated by *profichi* pollen, the rare *mammoni* male flowers not developing until two months later. The *mammoni* or summer generation produce a few male flowers in the same position, and the *mamme* or winter generation none, or only a few imperfect flowers. The *mamme* and *profichi* never produce seeds; the *mammoni* a very few only.

There are two or three exceptions to the normal noted above. As in most diœcious species, monœcious forms of figs occur, though rarely. There are, for example, male flowers occasionally produced in cultivated figs, and on the other hand, there are nearly always a very few female flowers

**Blastophaga psenes* of Cavolini, perhaps not of Linnaeus whose *Cynips psenes* was based on the account of Hasselquist, edited by Linnaeus, and published in 1757, and included Hasselquist's two species, *Cynips ficus* and *Cynips caricæ*. Both these species were described as '*Corpŭs totum rufum*,' and, as Mayer points out in opposition to Loew, can scarcely apply to *Blastophaga*. Hasselquist's names having been published before 1758, the earliest available descriptions of indubitable application to the fig insect and its common messmate are, respectively, *Ichneumon psenes* and *Ichneumon ficarius* of Cavolini, published in 1782, the latter of which should be known as *Philotrypesis ficaria* (Cavolini).

in the summer generation of caprifigs (*mammoni*), although Count Solms-Laubach found only twenty seeds in forty *mammoni*. Perhaps one flower in 2,000 is female, the others being gall flowers.

Then, too, there is a fig, called Erinosyche, which according to Pontedera bears *profichi* like a caprifig, and then a summer generation of ordinary edible figs; also the Croisic fig of Brittany and the Cordelia fig of California, which have a zone of male flowers above the ordinary edible part. This upper portion of the fig, bearing the male flowers, remains tough and inedible. Such abnormalities have, however, many analogies in other groups of plants, and do not obscure the fact that the edible fig is, as Hegardt contended in 1744, the female form, and the caprifig the male form of a dicœcious species. The remarkable feature of the fig is that its male receptacles bear gall flowers which are only slightly modified female flowers, and that these gall flowers harbor insects which pollinate the female fig flowers, and lay eggs in succeeding generations of caprifigs. The symbiosis is doubtless one of the oldest known, all of the hundreds of species of figs being inhabited by insects of a special family, Agaonidæ, which are all remarkably adapted to their peculiar habitat, while the figs appear as if specially constructed to nourish and protect the insects on which they are completely dependent for pollination. Both the insects and the plants are much more profoundly modified than are, for example, the Yucca and its moth, Pronuba.

CAPRIFICATION.

Herodotus (484–408 B. C.) seems to have known caprification, and Aristotle about 340 B. C., gave a perfectly clear account of it as follows:* "The figs of the caprifig contain small animals which are called *psenes*. These are at first small grubs, and when their envelopes are broken, *psenes* which fly come out; they then enter the fruits of the fig tree; and the punctures which they make there prevent these fruits from falling before they are ripe. So the countrymen take the trouble to put branches of the caprifig in the ordinary fig trees, and also plant caprifigs near the common fig trees." Theophrastus, his pupil, gave a more extended account, and for the first time noted that not all sorts of figs needed caprification.

This operation as now practiced consists in suspending in the fig trees strings of ripe caprifigs of the spring generation, containing the fig insects ready to emerge. The spring generation caprifigs, or *profichi*, are ripe in June or July, just when the young edible figs are large enough to allow the insect to enter the mouth, and when the female flowers are receptive. These spring generation caprifigs contain abundant male flowers, so that when the insects leave them and enter the young figs they carry pollen to the receptive female flowers. It should be noted that the insect is unable to lay her eggs in the normal female flower of the edible fig, and frequently dies within it. The female fig tree is therefore a death trap for the individual insect, although providing indirectly for a future supply of caprifigs. It thus appears that with these insects the less discriminating individual is the benefactor of the species. Only a few insects enter a single fig.

Caprification has been known for at least 2,300 years in the Eastern Mediterranean, and is still universally practiced in the fig regions about Aidin (near Smyrna) in Asiatic Turkey, at Kalamata in Western Greece, and in Kabylia, Northern Africa, the three greatest centers of production of dried figs. It is also frequent in Sicily, South Italy and Spain, but is not possible in cold countries near the northern limit of fig culture, because the insect could not

* History of Animals, Book 5, ch. 26, p. 4.

pass the winter where the *mamme* or winter caprifigs are liable to freeze.

Caprification is sometimes practiced on the caprifig itself in spring when the tree happens to bear no winter generation fruits. In such cases *mamme* from other trees are suspended in the branches, and the insects coming from them enter and lay eggs in the young spring generation caprifigs (*profichi*). Except for such caprification the *profichi* on such trees would not contain fig insects, and would be valueless for caprifying the edible fig in summer.

CAPRIFICATION IN AMERICA.

In 1880 and 1882, Mr. J. P. Rixford, of the San Francisco *Bulletin*, imported into California, by the aid of Consul E. F. Smithers, some fourteen thousand cuttings of the best sorts of Smyrna fig trees, it having been found impossible to prepare from any of the figs then cultivated in California a dried article able to compare with the best Smyrna product. These *Bulletin* cuttings were widely distributed, and hopes ran high until it was found that the trees refused to hold their fruit. The failure was absolute—not a single fruit has ever ripened during these nineteen years of culture, except some few hundred, pollinated by hand, as will be explained below. Believing that the Smyrniots, fearful of competition, had not sent the right sorts, many growers became disgusted and dug up their trees.

In 1890, Mr. George C. Roeding, of Fresno, produced the first Smyrna figs ever ripened in California, by artificially transferring the pollen from the caprifigs to the young Smyrna figs. In 1891, Dr. Eisen repeated this experiment at Niles. It was necessary to shake the pollen out of the caprifigs and introduce it with a quill into the young fig. From this time it became evident that it would be necessary to import the *Blastophaga*, since the artificial fertilizing of the figs was too slow and too expensive an operation to be applied in practice in the culture of Smyrna figs.

In 1890 also, the Division of Pomology of the Department of Agriculture had imported and distributed cuttings of these male or caprifig trees, together with the insects, but the latter were, of course, unable to survive in the absence of trees producing the necessary succession of caprifigs. Mr. James Shinn, of Niles, secured the insect in the summer of 1891, and Mr. Anthony C. Denotovitch in 1895, but in both cases with no result. Dr. Riley, then Entomologist of the Department, had devoted much thought to the matter, and in 1891 and 1895 he published papers calling attention to the importance of introducing the insect.

Having become interested in the subject of caprification through acquaintance with Dr. Paul Meyer while studying at the Naples Zoological Station in 1896, and having had placed at my disposal, through the liberality of Director Dohrn, the unequaled facilities of that institution, I entered upon a second and more detailed study in 1898. In this I was most kindly assisted by material and suggestions from Dr. Meyer and Count Sohms-Laubach. While engaged in this investigation, the results of which are soon to be published, a test was made, on private responsibility, of a method of mailing the winter caprifigs wrapped in tinfoil after the cut end had been sealed. This simple expedient proved effective, and the contained insects reached California in good condition. Meanwhile Dr. L. O. Howard, Entomologist of the Department of Agriculture, had determined to attempt the introduction of the *Blastophaga* and was in California in the interest of such an undertaking. The shipment accordingly received his personal attention. Although the insects failed to establish themselves, the experiment showed the advantage of sending the small, firm, winter caprifigs rather than the larger and softer spring generation, which had been

used in previous attempted introductions. In the spring of 1899, while traveling for the Section of Seed and Plant Introduction, I again sent winter caprifigs from Naples, and also, in considerable numbers, from the fig-producing regions of the mountains of Algeria. These also endured the journey well, and on arrival at Washington they were turned over to Dr. Howard, under whose direction they were liberated by Mr. Roeding in his extensive orchards at Fresno. This time the introduction was successful, and *Blastophaga* is now breeding in California, and, it is hoped, may pass the winter and become permanently established.

The principal fig growing regions of North Africa, Italy, Greece, and Asia Minor were also visited in order to learn the methods of culture there pursued, and the conditions necessary to the life of the insect. In the spring of 1898, when the fig orchards about Smyrna were severely frozen, the extraordinary price of from one to three dollars a pound was paid for caprifigs from islands of the Archipelago and from Western Greece, to be used in restocking the orchards with the *Blastophaga*. From one to two cents a pound is the ordinary price of caprifigs. Some lucky owners of large caprifig trees realized fabulous sums for their crop, much more than would ever be obtained from a tree producing edible figs.

Caprifigs are by no means all wild, as commonly supposed, but are extensively propagated and exist in several named and well-known varieties in Greece and Asia Minor. It is further worthy of note that the *profichi* which are produced by certain trees often have a value greatly superior, and there is reason to suppose that some sorts produce not only more *profichi*, but more insects to the fig, and furthermore do not harbor the mess-mate, *Philotrypesis ficaria*, which is considered injurious by growers. I was shown a fig tree in Algeria to secure the fruits of which natives often journeyed twenty or thirty miles. Another yielded *profichi* which sold in 1897, for seven dollars; and in Patras, Greece, I saw a third tree which had brought in as much. These facts give some idea of the views of the natives as to the importance of the process of caprification, which, indeed, all testimony agrees in proving to be *absolutely necessary* for securing a crop in all figs of prime commercial value in the dried condition.

Walter T. Swingle.
U. S. Dept. of Agriculture.

SCIENTIFIC BOOKS.

Praxis und Theorie der Zellen- und Befruchtungslehre. By Professor Valentin Häcker. Jena, G. Fischer. 1899. 260 pp. 137 Figs.

The last decade has witnessed the appearance in a large number of biological laboratories of a new course of study, now becoming generally known as cellular biology or cytology, which has created new demands in the way of text-books and laboratory methods. In its morphological aspect this study is nearly related to, and strictly speaking forms a part of, the older histology; though a practical ground of distinction lies in the fact that cytology is principally concerned with the anatomy of the cell considered as an individual, while histology includes also the comparative anatomy of the tissues. Cytology covers, however, a much wider field than that of cell-anatomy, for a very important part of the study relates to the processes of cell-reproduction and cell-physiology, including the phenomena of cell-division, the maturation and fertilization of the germ-cells, the physiological relations of nucleus, cytoplasm, and other cell-organs, and many cognate problems relating to growth and development. The subject thus becomes one of very wide scope, and indeed joins hands with every branch of biology that can be studied from the cell-standpoint. As practically taught, however, cytology is still largely occupied with cell-morphology and reproduction, and the historical development of the subject has been such as to concentrate the attention of cytologists to a considerable degree on the structure of the reproductive organs and on growth, division and

related phenomena, as displayed in the history of the germ-cells and in the early stages of embryological development. This tendency of cell-research, with which students of cytology are sometimes reproached, is not wholly due to the high theoretical interest of the germ-cells. It is in large measure a result of purely practical conditions, such as the large size of the cell-elements in germ-cells or embryonic cells, the ease with which they may be obtained in all stages of development, and the accurate control of results thus rendered possible. Similar reasons may be given for the large share of attention that has been devoted to special forms of tissue-cells, such as the epithelial cells and leucocytes of salamander-larvæ, or the embryonic cells of plant-tissues. Cytological teaching has inevitably followed in the main, the lines of research; and thus it has come to pass that in practice, courses in cellular biology cover a very different field from those in histology, requiring special material and employing special methods.

Botanical students have been fortunate in the existence of Strasburger's well-known *Botanisches Practicum* which, though primarily devoted to general botanical morphology, also contains valuable directions for the practical study of plant-cytology. Students of zoology have had no lack of general works, such as those of Flemming, Carnoy, Bergh, Hertwig, Henneguy and Wilson, not to mention a number of admirable works on histology; but with the exception of Carnoy's *Biologie Cellulaire*, published fifteen years ago and the first of its kind, none of these works contain practical laboratory directions. Carnoy's work is now too far out of date to be of much service to the modern student, and the same applies to Whitman's excellent *Methods in Microscopical Anatomy and Embryology* published in 1885. A. Bolles Lee's *Microtomist's Vade-mecum*, especially in the German edition, translated and revised by Paul Mayer, is indispensable to all students of microscopical anatomy, yet even this work does not supply the want which Häcker has now endeavored to meet.

The '*Praxis und Lehre*' will, we feel sure, be of the highest service both to students and to teachers of cytology. As the name indicates, it is not properly a laboratory manual, but happily combines practice with descriptions of fact and the discussion of theory. The plan followed is to describe a series of 'objects,' each accompanied by practical directions for the collection and preparation of material, a brief and clear account of the topic which it illustrates, and a review of the earlier history and more recent literature of the subject. The methods, like many of the descriptions, are in the main compiled from recent original works, and the author has wisely omitted all accounts of elementary operations such as the use of the microscope, methods of section-cutting and the like, which are adequately treated in Lee's and other manuals. The student is thus brought directly to the real subject-matter and is enabled to gain a connected idea of the facts, learning at the same time how to procure and prepare the material for first-hand knowledge. Some of this material, it is true, is not readily procurable, some is practically out of the reach of all who are not specialists. Professor Häcker has none the less rendered a good service, especially to teachers, by bringing together in readily available form the widely scattered accounts of material and method given by special investigators. The book is a model of clearness and brevity, and is well illustrated by figures drawn as far as possible from the latest sources. While we do not doubt that further experience will suggest many improvements on the practical side, the book may be heartily recommended as a most useful adjunct both to lecture-courses and to practical work in cytology, and one that cannot fail to give a stimulus to the study.

E. B. W.

The Teaching Botanist. By WILLIAM F. GANONG, PH.D., Professor of Botany in Smith College. New York, The Macmillan Company. 1899. Pp. xii + 270. Price, $1.10.

The growth of interest in the teaching of botanical science has found expression in the publication during the past few years of a liberal number of books, concerned in one way or another with this teaching. Up to this time these works naturally fall into two categories—that of the text-book and of the laboratory manual—and although some attempt has been

made to combine the virtues of these two classes in one book, no very marked result has been delivered. Attempts have also been made to embody advice and suggestions to the teacher in minor paragraphs, but these have been necessarily meagre and their educational value somewhat doubtful. The teaching body, therefore, has been waiting for the right kind of help—help which is not sandwiched into the text-book or into the laboratory manual, but designed for the teacher solely. This has been given them in the work before us, one which is divided into two parts, the first part consisting of 'Essays on Botanical Pedagogics,' the second of 'An Outline for a Synthetic Elementary Course in the Science of Botany.' The author in his preface calls attention to the fact that in the opinions of many teachers the 'vital phenomena, especially as they manifest themselves in moulding the physiogomy of vegetation,' should form the backbone of an elementary course in botany, and while admitting the value of this as an ideal, remarks that the problem of the topography of vegetation is far too complex a matter, too far beyond our understanding to be available in general courses. It appears to the reviewer that this is well said, for we are now experiencing a swing of the pendulum towards the use of ecology which will have to be lessened before the proper mean is arrived at. Passing on to the introduction we find the key to Professor Ganong's position as to what should constitute an elementary course. He says, "it must embody the essence of the best human knowledge of the leading divisions of the science, and that it must include training in those qualities by which that knowledge is gained."

The first part is made up of eight chapters, to the captions of which it is worth while here to draw attention. They are as follows: (1) The Place of the Sciences in Education and of Botany among the Sciences; (2) What Botany is of most Worth; (3) On Things Essential to Good Botanical Teaching; (4) On Scientific Recording, Drawing and Description; (5) On Laboratories and their Equipment; (6) On Botanical Collections and other Illustrations; (7) On Botanical Books and their Use; (8) On Some Common Errors Prejudicial to Good Botanical Teaching. It must be left to the titles to suggest the scope and usefulness of these essays, with the assurance that the one who is interested will not be disappointed. It may be well, however, to point out a few matters of special interest which will serve to indicate the character of the whole. In facing the problem of the crowded curriculum, the author makes the plea that the Natural Sciences should be added to the curriculum as alternatives with the older well-established branches. Following which is an argument for a limited elective system in the schools. The contents of the second chapter has already been indicated in a sentence from the introduction. Among features deemed essential to good botanical teaching is a 'determination for incessant improvement.' This involves work in original investigation, as it is truly regarded as the only way in which the teacher can cultivate the right scientific spirit. In the sixth chapter the matter of collections is dealt with; the author emphasizes the necessity of making a collection mean something, which is seldom enough the case. We have passed beyond the cabinet stage of development. The last of the chapters deals with common botanical errors, most of which grow out of the partial failure on the part of teachers to readjust themselves to the newer phases of botanical thought, and although this chapter would be unnecessary, if the contents of the third essay had not been violated, it is under the circumstances not the least necessary of the series, as the reviewer can say from his own experience in contact with teachers. The value of these essays is here only suggested, and while it is certain there will be some disagreement as to minor features—for when has there been entire agreement among the teachers?—the whole forms a well-balanced, corrective and stimulating body of matter.

The second part embodies in outline what in the author's experience has proved to be the most profitable course of study for elementary students. The course consists in the study of the seed, germination, the seedling and the differentiated plant, with inquiry into the structure, physiology and ecology of the same. A series of a dozen simple experiments has been worked out to illustrate the essential physiolog-

ical processes in plants and is here presented. Following the treatment of the Spermatophytes in the manner indicated is work on the great groups of plants. There will be some who will take exception to the choice of types. Marchantia, for example, is a very antiquated and highly respectable laboratory type and possesses historical inertia, but it is hardly the best possible representative of the Hepaticæ. Concerning these outlines it may be said that only the broad lines are laid down, and plenty of work is left for the teacher to do in intelligently planning the details of the laboratory work. The most valuable and distinctive feature in this portion of the book is the discussion of the pedagogics involved in each stage of the course. These must be passed with bare mention, though they deserve full treatment.

It is satisfactory to know that morphological study is considered of great value in the training of students and that the diagrammatic rather than the artistic representation should be required.

A few inadvertencies have crept in. Longitudinal sections of a Scilla or Hyacinth flower passing through two stamens will not give an appearance of the ovary as represented in pages 239 and 240, as such sections would pass through one of the partitions. It is not at all certain that the willow flower is theoretically primitive, and much more uncertain is it that 'color develops * * * to show where the nectar is.' Insects at least, it appears, are probably color-blind, but possess a keen sense of smell. And it is to be hoped that the essay on page 175 will not be read as an example without drawing attention to the incorrect use of the word 'endosperm,' for which 'food materials' would better be substituted.

Altogether, however, we have in Professor Ganong's book a very useful and timely work, which will surely do a great deal towards the bettering of botanical teaching in the schools, and one, moreover, as unique as useful.

FRANCIS E. LLOYD.

TEACHERS COLLEGE.

Reye's Geometrie der Lage. Lectures on Geometry of Position. By THEODORE REYE, Professor of Mathematics in the University of Strassburg. Translated by THOMAS F. HOLGATE, M.A., Ph. D., Professor of Applied Mathematics in the College of Liberal Arts in Northwestern University. New York, The Macmillan Company. 1898. Part I., 8vo. Pp. xix + 248.

As is well known this book, of which the first edition was published not more than thirty years ago, is the outgrowth of lectures delivered before the engineering students in the Polytechnic school at Zürich. These students were later to take lectures on Graphical Statics by Professor Culmann who, in the treatment of his subject, made free use of Von Staudt's 'Geometrie der Lage.' To get the most out of Culmann's work it was necessary that the student should not only be well acquainted with the conics, quadric surfaces, etc., but that he should also have what may be called a well-cultivated geometric imagination, in order that he might easily realize for himself a clear mental picture of the space figures which play such an important part in the engineer's work.

It is hardly too much to say that for the special purpose he had in view, no better means than the projective geometry could have been employed by Professor Reye; and one who has read his masterly treatment of the subject must always be grateful to him for the pleasure and profit derived therefrom.

It seems to us that there is a rapidly growing interest in pure geometry in this country, and that its real merit as an instrument of education is coming to be more fully recognized. Rightly presented, the charm of the subject itself, which is free from the trammels of the metric geometry of Euclid, is immediately experienced by students.

Although the geometry of position is often introduced by means of cross ratios, which (at least apparently) involve measurements, yet Reye's treatment is entirely free, even at the beginning, from any dependence upon metric relations. He has, however, beautifully shown that metric relations, especially those connected with the conic sections, present themselves very naturally as special cases of general non-metric theorems.

This, of course, may also be said of two other excellent books, viz., Cremona's 'Projective Geometry' and Von Staudt's 'Geometrie der Lage'; but Von Staudt is too brief to be easily

read by a beginner, and Cremona, as translated by Leudesdorf, seems rather unattractive, and certainly lacks the charm of Reye's lucid style.

It seems to us, therefore, that the translator has rendered a great service to English-speaking students in translating this first part of Reye, and we earnestly hope that sufficient interest in the study of pure geometry will be awakened by having this very attractive book available for beginners, to make him feel that his unselfish labor has not been in vain.

Whether it is worth while to translate the other parts also (Parts II. and III. carry the subject far beyond its elements) is, however, very questionable—because those of our students who are sufficiently advanced to understand the subjects treated are able to read the German about as readily as the English.

The translation itself is also, as a whole, to be heartily commended; the charm of the original has been preserved, many valuable exercises have been added, and the breaking up of the lectures into numbered paragraphs, as well as the rearrangement of the exercises so as to have those that are appropriate thereto follow each lecture, are distinct improvements.

It is, however, to be greatly regretted that the translator has seen fit to change a well-established and everywhere understood terminology. For example, he replaces the terms *pencil* and *sheaf* (which are already, and for many years have been, well-nigh universally employed to represent particular geometric concepts), respectively by the terms *sheaf* and *bundle*. While it may be granted that these new terms are in themselves just as good as, and possibly even a trifle better than, those for which they are substituted, yet nothing of importance is gained by the change, while the danger of confusion and misunderstanding is greatly increased.

J. H. Tanner.

Cornell University, October 4, 1899.

BOOKS RECEIVED.

Bacteria. George Newman. New York, G. P. Putnam's Sons. London, John Murray. 1899. Pp. xiv + 348.

Cambridge Natural History. Vol. V. *Insects.* Part II. David Sharp. London and New York, The Macmillan Company. 1899. Pp. xii + 626.

A Dictionary of Birds. Alfred Newton, assisted by Hans Gadow. New York, The Macmillan Company. London, Adams & Charles Black. 1893–1896. Cheap issue, unabridged. Pp. iii + 1088. $5.00.

The Insect World. A Reading Book of Entomology. Clarence Moores Weed. New York, D. Appleton and Company. 1899. Pp. xvi + 210.

Indicators and Test-Papers. Alfred I. Cohn. New York, John Wiley & Sons. London, Chapman & Hall, Ltd. 1899. Pp. ix + 249.

A System of Medicine by Many Writers. Vol. VIII. *Diseases of the Nervous System.* Continued. Edited by Thomas Clifford Allbutt. New York and London, The Macmillan Company. 1899. Pp. xii + 937. $5.00.

SCIENTIFIC JOURNALS AND ARTICLES.

The Journal of Physical Chemistry, October, 'On the Paraanisaldoximes,' by H. R. Carveth: a study of the two modifications; 'On the Relation between Pressure and Evaporation,' by Edwin H. Hall; 'The Electrical Conductivity of Non-Aqueous Solutions,' by Azariah T. Lincoln: an account of the experimental work of the author, chiefly with chlorides (also silver and lead nitrates, silver and mercuric cyanids, mercuric iodid and copper sulfate), in a well-selected variety (27) of solvents, all organic except PCl_3 and $SuCl_4$. Some substances were insoluble, some insoluble but not conductors of electricity, while others conducted electricity well. Two conclusions of the author may be quoted: "The data collected are as yet insufficient to show what the relation between solvent and dissolved substance must be in order to yield solutions that conduct electricity." "The dissociation theory as promulgated for the explanation of the electrical conductivity of aqueous solutions, apparently cannot be applied in its present form to explain the conductivity in non-aqueous solutions." The article is an important contribution to the study of solutions.

J. L. H.

SOCIETIES AND ACADEMIES.

NEW YORK ACADEMY OF SCIENCES. SECTION OF BIOLOGY.

The regular meeting of the Section of Biology was held on Monday evening, October 9th, Professor Frederic S. Lee presiding. The

minutes of the previous meeting were read and approved. The following persons were nominated for membership in the Academy: Mr. Maurice A. Bigelow, of Teachers College; Dr. Edward L. Thorndike, of Teachers College, Mr. R. S. Woodworth, of University and Bellevue Hospital Medical College, and Dr. W. Golden Mortimer, 504 W. 146th Street, New York City.

The evening was devoted to reports of the past summer's work by a number of members.

Professor H. F. Osborn gave an account of the exploration by the American Museum party in the Como beds of Southern Wyoming, and of further work in the Bone Cabin Quarry, which resulted in the discovery of a large number of the remains of Dinosaurs. Four miles distant a *Brontosaur* skeleton was found. Parties were also sent to the Freeze Out Mountains and north to the Rattlesnake Mountains, but without success.

Professor E. B. Wilson reported upon his search in Egypt for *Polypterus*, which resulted in the obtaining of a few fine females, but with unripe ovaries; this was in winter, between Assuan and Mansourah. Professor Wilson reported, also, the rediscovery by him of the gill-bearing earthworm, *Alma*.

Professor Bashford Dean reported on the work of the second Senff expedition to the Nile, and spoke of the death of Nathan Russell Harrington, the senior member of the party. Mr. Harrington had for four years identified himself with the Biological Section, and had left with it an enviable example of energetic and persistent effort to complete an important research and of sacrifice and devotion to a life work.

Professor Dean further reported on his work on the California coast while a guest of Stanford University. He was successful during the present summer in obtaining a number of freshly hatched young of *Bdellostoma*, and many developmental stages of *Chimæra Colliei*.

Dr. G. N. Calkins reported the passing of a successful summer at the Marine Biological Laboratory at Woods Hole, where he was at work upon the Protozoa.

Professor F. E. Lloyd gave a brief account of a collecting trip in Vermont, embodying some remarks upon certain species of *Lycopodium* found there. He also reported upon the marked success of the Biological Laboratory at Cold Spring Harbor during the summer.

Professor F. S. Lee spoke on the continuation of his experimental work upon the lateral line in fishes, conducted at Woods Hole.

FRANCIS E. LLOYD,
Secretary.

DISCUSSION AND CORRESPONDENCE.

'THE PERCEPTION OF HORIZONTAL AND OF VERTICAL LINES.'

TO THE EDITOR OF SCIENCE: In connection with Professor Peirce's article on 'The Perception of Horizontal and of Vertical Lines' (SCIENCE, September 29, 1899), it may be appropriate to call attention to a study of the same question made in the Psychological Laboratory of the University of Wisconsin and published in the *American Journal of Psychology* in 1893 (Vol. V., pp. 214–223). Our method consisted in seating the observer under a parasol-like canopy, which completely screened from him all the horizontals and verticals of floor and walls; in then placing opposite him under the canopy a large black disc, upon which was centered a smaller white disc bearing upon it a single line; and in requiring the observer to set this line (by means of strings manipulated by his hands which were outside the canopy) so that it appeared horizontal or vertical. The observer is thus everywhere surrounded by curved outlines, and has no standard to guide him except the ideal one which he carries in his mind. So far as the results of the two investigations are comparable they agree very well, both emphasizing the great accuracy of such 'mental' judgments. Our estimations were made binocularly under circumstances approximating those of the ordinary use of the eyes; Professor Peirce's subjects in the first group of experiments used each eye separately. If we may assume that the average setting of the two eyes used separately is equivalent to the binocular setting of the lines, and further allow that the two methods used are fairly comparable, we find for the mean deviation for Professor Peirce's subjects (average of ten subjects) for the horizontal $+.25°$, for my ten subjects $+.12°$; for the vertical $-.39°$ and $+.23°$. It is better, however, to compare my results with Professor

Peirce's binocular results obtained by looking through a tube 35 centimeters in diameter and 2 meters long. The mean deviation for the horizontal then becomes (average of 29 subjects) —.25° and for the vertical —.56°. The settings are so nearly correct that the direction of the error cannot be regarded as significant; in both sets of observations the excess in number of those who tended to one type of error was not very great upon those who tended to the contrary type. I also investigated the errors for oblique settings. These proved to be much greater, on the average about nine times as large, and with a pronounced tendency to set both the oblique lines in a position nearer the horizontal than the two 'ideal' oblique lines making angles of 45° with the horizontal and vertical.

In the same group of contributions from the Laboratory of the University of Wisconsin may also be found a study of the accuracy with which lines could be set in given positions, when a model or copy was furnished; and a study of the accuracy with which angles may be reproduced.

The variations in the manner of estimating which Professor Peirce has introduced are extremely interesting and contribute something of value to the determination of the factors which influence such judgments of position. I can recall that at the time we were engaged in these investigations, I had in contemplation a set of experiments in which the subject should be required to set vertical and horizontal lines in a room in which contained no true verticals or horizontals or rectangular dimensions. The floor was to be slightly out of the horizontal in one direction, the ceiling in another, while the walls might present various kinds and degrees of divergence from the vertical. How far such an unusual environment might effect one's estimate of the true horizontal and vertical seems an interesting subject of inquiry.

Joseph Jastrow.

Psychological Laboratory, University of Wisconsin, Madison, Wis., October 5th.

THE THIRD PRINCETON EXPEDITION TO PATAGONIA.

Mr. J. B. Hatcher and his assistant, Mr. O. A. Peterson, have returned from their third exploration of Patagonia, where they were sent by the Geological Department of Princeton University. The work has been highly successful and admirably supplements that of the two previous journeys. We hope to give later a more detailed report of the results of the expedition, but may state at present that the party sailed from New York on December 9, 1898, and returned August 17, 1899, bringing very extensive collections of both vertebrate and invertebrate fossils of Patagonia, together with much material illustrating the zoology and botany of that region. The work of cleaning and preparing these great collections for study and publication has already made good progress, and is being pushed forward as rapidly as possible.

In a recent report Mr. Hatcher summarized the results of the work for the last three years as follows:

"(1) A good preliminary geological survey of that part of southern South America, lying between the Andes on the west and the Atlantic on the east, and between the Straits of Magellan and the forty-seventh parallel of south latitude, sufficient to serve as a basis for a geological map of the region.

"(2) Very extensive and complete collections of fossils from all the different fossil-bearing horizons known to that region, with the one exception of the Pyrotherium beds.

"(3) The discovery of four distinct and previously unreported geological horizons.

"(4) A collection of more than one thousand skins and skeletons of recent birds and mammals, embracing about one hundred and fifty species of birds and fifty species of mammals, and fairly representative of the mammalian and avian life.

"(5) Extensive collections of the fresh water, terrestrial and litoral invertebrate life.

"(6) Botanical collections, especially of the mosses, Hepaticæ and flowering plants, not including the grasses and sedges."

(7) To the above should be added a large and very valuable series of photographs, illustrating the geology and physical geography of Patagonia.

It is hoped that a series of adequately illustrated monographs will be issued from the Princeton museum containing the results of the

study of these great collections. The geology will be treated of by Mr. Hatcher, the Tertiary invertebrates by Dr. Ortmann, the fossil vertebrates by Messrs. W. B. Scott and Hatcher, and the recent birds by Mr. W. E. D. Scott.

It is difficult to exaggerate the value of Mr. Hatcher's and Mr. Peterson's long and arduous labors. Materials have now been gathered that will make possible the solution of many vexatious and much discussed problems, and for the first time a full and representative collection of the wonderful fossil mammals of Patagonia has been brought to a Northern museum. We can, at last, directly compare the Tertiary mammals of the Northern and Southern Hemispheres, and may hope to reach some definite conclusions concerning the mutual relations of these two faunal assemblages.

A LONG PHOTOGRAPHIC TELESCOPE.

LAST spring a plan was proposed at the Harvard College Observatory for the construction of a telescope of unusual length for photographing the stars and planets. Anonymous donors have now furnished the means by which this experiment may be tried. The plan will, therefore, take definite shape, and it is expected that a telescope, having an aperture of 12 inches and a length of a hundred feet or more, will be ready for trial at Cambridge in a few weeks.

EDWARD C. PICKERING.

HARVARD COLLEGE OBSERVATORY,
October 12, 1899.

SCIENTIFIC NOTES AND NEWS.

WE announce with great regret the death on October 16th, of Dr. Edward Orton, the eminent geologist, professor in the Ohio State University, president of the American Association for the Advancement of Science.

DR. J. T. ROTHROCK has been reappointed for a term of four years, State Commissioner of Forestry for the State of Pennsylvania.

PROFESSOR GEORG STEINDORFF, tne director of the Ægyptologische Sammlung at Leipzig, has, says *Nature*, obtained leave of absence for six months to enable him to undertake a scientific journey to Africa.

IT is stated in *Natural Science* that Dr. Robert Logan Jack, late Government Geologist for Queensland, and special commissioner in charge of the exhibits at the Greater Britain Exhibition, has accepted an appointment from Mr. Pritchard Morgan to run some mining concessions in Szechuan, Korea, and North China. Dr. Jack sailed in September.

AT a sitting of the International Geographical Congress on October 2d, it was announced that Dr. Scott Keltie had received a telegram from Mr. H. J. Mackinder, the reader in geography at Oxford, who has just succeeded in reaching the summit of the hitherto unscaled Mount Kenia (about 18,000 feet), in British East Africa. Mr. Mackinder left England in June last in command of an expedition subsidized by the Royal Geographical Society. The telegram, which was sent *via* Mombasa, states that some 15 glaciers were found upon the mountain.

DR. G. W. HILL will give a course of lectures on celestial mechanics at Columbia University on Saturday mornings beginning October 21st. The subjects treated will be:

I. Delaunay's Method in the Lunar Theory generalized and applied to the Planets.
II. Gyldèn's Method of Perturbations.
III. Gauss' Method with Secular Perturbations.
IV. General Expressions for the Secular Inequalities of the Solar System.
V. Poisson's Theorem on the Invariability of the Mean Distances.
VI. Periodic Solutions in the Planetary Problem.
VII. The Restricted Problem of Three Bodies.
VIII. General Considerations on the Stability of Motion of Planetary Systems.

PROFESSOR R. W. WOOD, of the University of Wisconsin, having received several inquiries as to whether he could furnish lantern slides of the plates illustrating his article on the photography of sound-waves, which appeared in the *Philosophical Magazine* for August, has placed the original negatives in the hands of Miss Blanchard Harper (Madison, Wis.), who is prepared to supply slides from any or all of the plates at a nominal cost. The slides will be found useful in teaching, showing as they do the wave fronts by reflection from all sorts of surfaces, refraction, diffraction, Huyghens' principle, etc.

MAJOR RONALD ROSS has now returned from Africa, and is represented to have said that the authorities in Sierra Leone, acting on his advice, are now destroying the virulent mosquito by every means in their power. In the judgment of Major Ross the future of the west coast will be assured as soon as the colonial authorities take similar steps in the neighborhood of the principal towns, although years must elapse before the inland stations are improved.

THE Vice-Chancellor of Cambridge University announced on October 4th that he had received the following communication from the Colonial Office: The Government of the Straits Settlements desires to invite the attention of Radcliffe's travelling Fellows and of holders of scholarships for medical and physical research to the study of the tropical diseases called beriberi. This disease caused in the hospitals of the colony 730 deaths in 1896, and 692 in 1897. This government will be glad to assist any scholar who desires to engage in the scientific investigation of this disease in the colony, by providing him with furnished quarters, rent free, by giving him free access to all the hospitals, and facilities for studying the cases therein, by defraying the cost of his passage to the colony, and in any way which may be agreed upon hereafter between the scholar and Mr. Swettenham, the Secretary of the Straits Settlements.

THE death is announced of M. Paul Janet, member of the Paris Academy of moral and political science, and formerly professor of philosophy at the Sorbonne.

MR. EDWARD CASE, an English engineer, well known for his method of groyning to prevent the sea from encroaching on the coast, died on September 22d.

THE position of assistant in the bio-chemic division of the Bureau of Animal Industry in the Department of Agriculture, will be filled as the result of an examination on November 7th. The chief subject in the examination will be serum therapeutics. The salary will be $750 per annum.

THE charter of the Dental School and Museum of Art, provided for in the will of the late Dr. Thomas W. Evans, the American dentist, who died in Paris in 1897, has been approved by Judge Arnold. The Museum will have an endowment of nearly four million dollars unless the will is broken by the legal contest now in progress.

Mr. Andrew Carnegie has increased his gift for the Washington Public Library to $350,000. At the close of the last session a site on Mount Vernon Square was selected, and it is expected that the construction of the building will be begun very soon.

WE learn from *Popular Astronomy* that the new observatory and great refractor of the astrophysical observatory at Potsdam were inaugurated on August 26th, in the presence of the German Emperor.

THE fine collection of Scottish agates made by the late Professor Heddle says *Natural Science* is now arranged in the Museum of Science and Art in Edinburgh. Mr. J. G. Goodchild has prepared a guide to the collection, incorporating Professor Heddle's explanatory notes.

THE winter meeting of the American Chemical Society will be held at New Haven, Conn., during Christmas week. As last year in New York the Society will meet at the same time and place as the American Society of Naturalists and affiliated societies.

ABOUT seventy members of the British Association took advantage of the trip through France and Belgium arranged to follow the Dover meeting. They were officially welcomed in the different towns and cities that they visited.

THE Fourth International Congress of Applied Chemistry is to be held in Paris from the 21st to 23d of July, 1900, with M. Berthelot as honorary president, and M. Moissan as president. An American Committee on Organization has been formed consisting of: Section I.—*Analytical Chemistry*, W. L. Dudley, W. F. Hillebrand, J. H. Long, Elwyn Waller; Section II.—*Inorganic Products*, Edward Hart, Edward W. Morley, J. D. Pennock; Section III.—*Metallurgy, Mines, Explosives*, F. W. Clarke, C. B. Dudley, C. E. Munroe, H. H. Nicholson; Section IV.—*Organic Products*, Thomas Evans, Wm. McMurtrie,

Ira Remsen, Clifford Richardson, S. P. Sadtler; Section V.—*Sugar Industry*, Edward Gudeman, W. D. Horne, G. L. Spencer, M. Swenson, Edward B. Vorhees; Section VI.—*Fermentations*, C. A. Crampton, W. B. Rising, Alfred Springer; Section VII.—*Agricultural Chemistry, Fertilizers, Cattle Feeding, Dairy*, G. C. Caldwell, L. L. Van Slyke, H. W. Wiley; Section VIII.—*Hygiene, Medical and Pharmaceutical Chemistry*, W. O. Atwater, R. H. Chittenden, J. U. Lloyd, Wm. P. Mason, Wm. J. Schieffelin; Section IX.—*Photography*, C. F. Chandler, J. H. Stebbins, Jr., E. R. Hewitt; Section X.—*Electro-Chemistry*, Elihu Thomson, Edgar F. Smith, Charles A. Doremus, Chairman of the American committee.

THE Twelfth Congress of Orientalists convened at Rome on October 4th, with about 400 delegates in attendance.

AT a meeting of the Trustees of New York Public Library on October 11th, the Director, Dr. John S. Billings submitted his annual report. The number of books received for the 'shelf department' and catalogued in the year was 34,182, of which 16,994 were purchases and 17,188 gifts. The Ford gift is estimated at about 100,000 volumes and pamphlets. The total volumes actually received was 55,593, and the pamphlets 101,698. On the shelves and available for use at the end of the year were 459,248 volumes and about 117,000 pamphlets. The number of readers who visited the two buildings was 111,038. This is an increase of 7,000 over the previous year.

ACCORDING to *Natural Science* an interesting experiment is being made by the government of Bosnia and Herzegovina in connection with the subject of the migration of birds. A number of observatories are being established all over these two countries, on the coasts, plains, mountains, rivers and lakes—in fact, in every spot which seems likely to yield results of interest to those engaged in researches on bird migration. Under the auspices of the government of the two countries named, a meeting of ornithologists was convened at Sarajevo from the 25th to the 29th of September, with a view to similar observations conducted on uniform methods being instituted elsewhere. A report was presented on the bird life of the Balkan States, illustrated by a fine collection from those districts.

BOTANISTS should feel under obligations to us for calling their attention to the description of a new species, as it appeared in a daily paper where it might be overlooked. We regret that the n. sp. is not figured. The description is in the following paragraph from the London *Daily Chronicle*:

> The Pope takes great interest in an electric plant, to which he has given the name 'Officina Electrica Vaticana Alessandro Volta,' in honor of Volta. A few days ago his Holiness made a special inspection of these plants, and the employees of the Vatican gardens were presented to him by the chief.

UNIVERSITY AND EDUCATIONAL NEWS.

IN fulfillment of the terms of the will of the late Edward Austin, the president and fellows of Harvard College, have voted that, until they shall give further orders, $2,000 shall be assigned yearly from the income of his bequest of $500,000 to establish eight scholarships, each with an annual value of $250, to be awarded for one year to superintendents of schools and to teachers in secondary schools and colleges, who have been recently in service and intend to return to service. Several of these scholarships have been awarded including one to R. E. Gaines, professor in Richmond College, and C. V. Piper, professor of biology in the University of Washington.

D. F. CONVERSE, a mill owner of Spartanburg, S. C., who died a week ago, left one-third of his estate, valued at $500,000, to Converse College, an institute for the higher education for women founded by him in Spartanburg ten years ago.

THE expenses of the University of Chicago for printing and publishing during the academic year ending June 30, 1899, were over $44,000, whereas the receipts were only $17,000. It is probable that no other university supports its publications with such liberality.

PROFESSOR GEORGE HARRIS was formally inaugurated as President of Amherst College on October 11th. In the course of his inaugural address President Harris clearly stated that a scientific education has a culture value equal to

classical studies. He said that the high schools could not be expected to teach Greek, and that the colleges must accept the preparation given in the high school. "Granting that culture is the primary object of education, it does not follow that there is only one kind of discipline, as the classical—that the ancient languages and mathematics are the only regimen for making the man of letters. The equation of culture may have for its second term almost any actual knowledge." When study of the classical language "degenerates into mere language drill, and when thousands, in fact, never get beyond that, or cannot read a passage at sight, the value of such study is not obvious. Allow, however, the full worth of the classical discipline. Yet even so there are other studies now of equal or greater value."

THE inauguration of President Faunce, of Brown University, took place on October 17th. Addresses were delivered by Presidents Patton, Harper, Elliott and Faunce.

THE Council of the University of Melbourne will shortly appoint a professor to the chair of geology and mineralogy. *Natural Science* states that the professor is expected to devote the whole of his time to the work of his department, and will be required to deliver two courses of lectures of three hours a week each, and to undertake the training of students both in field and laboratory work. The salary of the professor is £1,000 per annum, but in the event of the Council providing him with a residence in the University grounds, the sum of £100 per annum will be deducted from his salary as aforesaid. The University has a fair collection in paleontology and mineralogy, but has no specially fitted up laboratory for geological work. A suitable room in the University buildings will be provided in which to organize this part of the work. Lectures begin in 1900, on Thursday, March 1st. The salary of the office will commence from the 14th February, 1900, or from the date of the Professor's arrival in Melbourne, if later than the 14th February. If the professor appointed come from Britain or America, £100 will be allowed for travelling expenses.

PROFESSOR J. B. JOHNSON was inaugurated as Dean of the College of Mechanics and Engineering of the University of Wisconsin on October 18th.

MR. CLARK WISSLER, of Ohio State University, has been appointed assistant in psychology in Columbia University.

DR. MERTON L. MILLER has been appointed to an associateship in anthropology in the University of Chicago.

DANIEL P. MACMILLAN, PH.D., '99, has received an appointment in the Child-study Department which was recently created in the public schools of Chicago.

THE following have been appointed instructors in zoology in the University of Michigan: Dr. H. S. Jennings (last year instructor at Dartmouth), Dr. S. J. Holmes and Dr. K. W. Genthe (Leipzig).

DR. J. B. JOHNSTON (last year instructor in zoology at the University of Michigan) has become assistant professor of biology at the University of West Virginia, Morgantown.

H. W. F. LORENZ, A.B. (Wittenberg), and Ph.D. (Berlin), has just assumed the position of instructor in organic chemistry in the University of Pennsylvania. Dr. Lorenz is the translator of Löb's *Organic Electrosyntheses*.

W. L. HARDIN, S.B. (Buchtel College), Ph.D. (University of Pennsylvania), who held the position of fellow and later senior fellow in chemistry in the University of Pennsylvania, has recently been appointed to an instructorship in the same institution. He is the author of 'Liquefaction of Gases' recently published by Macmillan & Company.

JOS. H. JAMES, Ph.D. (University of Pennsylvania), has just been appointed acting professor of chemistry in Buchtel College, Akron, O.

GEO. E. THOMAS, S.B., Ph.D. (University of Pennsylvania), has been elected instructor in chemistry in Swarthmore College, Pa.

MISS LILY G. KOLLOCK, A.B., (Woman's College), Ph.D. (University of Pennsylvania), has been appointed to an instructorship in chemistry in Vassar College.

HERBERT N. MCCOY, Ph.D. (Chicago), has been appointed instructor in chemistry in the University of Utah.